HARVARD UNIVERSITY.

LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

4370

Exchange.

October 1, 1917 – July 17, 1918.

JUL 17 1918

4370

Transactions

of the

Connecticut Academy of Arts and Sciences

Volume XXII

YALE UNIVERSITY PRESS
New Haven, Connecticut
1917, 1918

OFFICERS FOR 1917–18

President

HON. SIMEON E. BALDWIN

Vice-Presidents

PROF. ALEXANDER W. EVANS PROF. CLIVE DAY
PROF. CHARLES C. TORREY

Secretary

MR. GEORGE F. EATON

Treasurer

MR. GEORGE PARMLY DAY

Librarian

MR. ANDREW KEOGH

Committee on Publication

HON. S. E. BALDWIN, Chairman PROF. A. W. EVANS
PROF. A. S. COOK PROF. CLIVE DAY
PROF. E. S. DANA PROF. CHARLES C. TORREY
PROF. E. P. MORRIS MR. ANDREW KEOGH
MR. GEORGE F. EATON

CONTENTS

		Pages
Art. I.	The History of Early Relations Between the United States and China, 1784–1844 By Kenneth Scott Latourette	1–209
Art. II.	Studies in the Calcite Group By William E. Ford	211–248
Art. III.	The Vegetation of Northern Cape Breton Island, Nova Scotia . . . By George E. Nichols	249–467

OCT 3 1917

4370

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES

INCORPORATED A. D. 1799

VOLUME 22, PAGES 1-209 AUGUST, 1917

The History of Early Relations

between

The United States and China

1784—1844

BY

KENNETH SCOTT LATOURETTE

YALE UNIVERSITY PRESS

NEW HAVEN, CONNECTICUT

1917

LIBRARY
MUSEUM OF ZOOLOGY
HARVARD UNIVERSITY

OCT 1 1917

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 22, PAGES 1-209 AUGUST, 1917

The History of Early Relations between The United States and China 1784—1844

BY

KENNETH SCOTT LATOURETTE

YALE UNIVERSITY PRESS
NEW HAVEN, CONNECTICUT
1917

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

CONTENTS.

PAGE

Foreword 5

Introduction 7

Chapter I. The Period of Beginnings, 1784-1790 . . 10

Chapter II. The Period of Expansion and of War, 1791-1814 27

Chapter III. From the Close of the War of 1812 to the Outbreak of the Opium Troubles, 1815-1834 . . 53

Chapter IV. From the Close of the War of 1812 to the Outbreak of the Opium Troubles, 1815-1838 (*continued*).

The Beginnings of American Missions to the Chinese . 85

Chapter V. The Period of the Opium Troubles and of the First British-Chinese War, culminating in the Treaties of Nanking and Whanghia, 1839-1844 . . 110

Bibliography 145–200

1. Bibliographies 145
2. Official Documents and Reports of Societies . . 146
3. Manuscripts, Logs, Ship Accounts, Bills of Lading, and kindred documents 154
4. Journals, Diaries, Contemporary Descriptions, Correspondence, and Narratives of Voyages . . 160
5. Contemporary Pamphlets, Sermons, Lectures, Discussions, and Treaties 175
6. Newspapers and Periodicals 179
7. Secondary Authorities 183

Index 201

FOREWORD

The author wishes to make grateful acknowledgment of the courtesy of the many individuals and institutions whose helpfulness and courtesy have made this study possible. Especially is he under obligations to Professor Clive Day of Yale University, the Connecticut Academy, the Yale Library, the John Carter Brown Library, the Essex Institute, the Salem and New York Customs Houses, the Lenox Library and the great collection of which it now forms a part, the New York Public Library, the New Haven Colony Historical Society, the Rhode Island Historical Society, the New York Historical Society, the Boston Athenaeum and the Boston Public Library, the Harvard Library, the Library of Congress and the State Department, the American Board of Commissioners for Foreign Missions and the American Baptist Missionary Union, now the Baptist Missionary Society. Above all the author wishes to record his indebtedness to Professor Frederick Wells Williams of Yale University, under whose direction the study was originally made, in whose ample library much of the work was done, and to whose constant interest and kindly criticism are due much of whatever value these pages may have.

INTRODUCTION

The intercourse of western nations with China falls into two periods, the dividing line between which is the discovery of the sea route to India in the fifteenth century. In the first period come the vaguely known trade with the Roman Empire, the burst of commerce and papal missions made possible by the Mongol conquests of the thirteenth and fourteenth centuries, and the slight revival of indirect communication under Tamerlane and his successors.[1] The second period begins with the coming of the Portuguese in the early sixteenth century.[2] In the first period intercourse was largely by the overland route across the high table land of Central Asia. In the second, except in the case of Russia, it has been almost entirely by sea.

The second period is in turn separated into two natural divisions by the first British-Chinese war and the treaties of 1842-4. Before these years all Westerners were regarded by the Chinese as troublesome barbarians. They were looked upon as tributary peoples, uncivilized, not to be considered as equals. They were confined to limited quarters in the suburbs of one port, Canton, and to Macao, which Portugal had leased from the Empire. They were ruled by the most stringent of regulations, but were viewed with such contempt that officials would deal with them only through a non-official commercial monopoly, the co-hong.

In spite of handicaps, however, the commerce and missions of two countries, the United States and England, steadily grew, and when Chinese isolation and self-satisfaction finally became unbearable, the first British-Chinese war broke out and resulted in treaties which granted revolutionary concessions. With these treaties, China entered the family of nations, and theoretically at least, recognized western countries as her equals. Foreigners were allowed residence in five ports, were released from the old

---

[1] Henry Yule, *Cathay and the Way Thither*, being a collection of Medieval notices of China translated and edited by Colonel Henry Yule, with a preliminary essay on the intercourse between China and the Western Nations previous to the discovery of the Cape Route. London, 1866. This is the best single work on the period.

[2] S. Wells Williams, *A History of China*. New York, 1901. pp. 75-110.

cumbersome regulations, and were placed under their own laws and a more equitable system of port rules and duties. China still had a long road to travel before reaching a full appreciation of other powers and entering fully into modern life. Wars, rebellions, and outbreaks were to mark the mile posts. But in 1842-1844 she put her feet in the way, and the years since that date are rightly thought of as being spent in advancing toward the goal then first dimly seen.

It is the purpose of the following chapters to trace the part of the United States in the first division of the second period, i. e., the years before 1844. This will lead us to show how trade with China began, to trace its expansion, its changes, and its influence, to find the beginnings of American missionary effort for the Chinese and to see its early growth, and finally to consider the immediate effects of the first British-Chinese war and the British treaty on both commerce and missions, and to give the story of the first American treaty with the empire. As we proceed we shall find that there are well marked chronological divisions in our subject. The first includes the opening of the trade and its first few years. The second begins with the sudden expansion of commerce caused by the European wars and the discovery of new sources of furs, sandal wood, and *beche de mer,* and closes with the commercial stagnation of the Second War with Great Britain. The third begins with the conclusion of peace in 1814, and ends with the beginning of the opium troubles. The fourth and last begins with the opium troubles of 1839, includes the first British-Chinese war, and ends with the treaty of Whanghia, in 1844.

Practically all the known available material on the subject has been examined. Manuscript correspondence of persons intimately connected with the events narrated, especially that of the consuls at Canton, preserved in the State Department in Washington, and that of the missionaries of the American Board and the Baptist Board, preserved in the archives of these two societies, forms a considerable and important source of information. Manuscript logs, largely those preserved in the Essex Institute and belonging to Salem ships, and those of the firm of Brown and Ives of Providence, deposited in the John Carter Brown Library of American History, are also important. Published journals, correspondence, and especially narratives of voyages are also

indispensable. A surprising number of these, most of them long out of print, are to be found in nearly all of our large libraries. A few periodicals are very useful. One especially, the Chinese Repository, is an invaluable source. There are numerous biographies and memoirs, largely of missionaries, which cover this period, and a number of secondary authorities can be found which add useful information. Congressional documents and other government papers are of use, especially in tracing the negotiations which resulted in the Treaty of Whanghia.

CHAPTER I.

The Period of Beginnings, 1784-1790.

American commerce with China was the result of influences reaching back over an extensive period. At the very discovery of the New World a connection had existed with the Celestial Empire, for it was to find Cathay and the Indies that Columbus sailed westward, and it was partly the belief in a Northwest Passage through the continent to the same countries which led the European explorers of the sixteenth and seventeenth centuries to nose their way along the eastern coast of North America. Still later the English colonists became acquainted with China through the East India Company. Their tea came in the Company's ships from Canton by way of Great Britain. Since 1718, ginseng, the drug which formed a large part of the cargoes of the first China ships, had been known to be native to North America,[1] and it is probable that the East India Company had shipped some of it to Canton.[2] The Company may, too, have had some of its Indiamen built in the colonies.[3]

---

[1] A Jesuit, Joseph Francis Lafitare, in 1718 published his "Mémoire présenté à S. A. R. Mgr. le duc d'Orléans, régent du royaume de France, concernant la précieuse plante du ginseng, decouverte en Canada." Paris, 1718. Reuben G. Thwaites, "Jesuit Relations and Allied Documents," Cleveland, c. 1900, 66:333 (Notes); 71:347. See also Justin Winsor, "Narrative and Critical History of America." Boston and New York. c. 1886. 4:289, 298.

[2] William Speer, The Oldest and the Newest Empire, China and the United States, Hartford, 1870, p. 410, says that the East India Company used it as a return cargo to save exports of specie, and speaks of "Agents sent to New England, who induced Indians to search for this medicinal root by rewards of money, whiskey, trinkets, and tobacco." Hamilton, in his Itinerarium of 1744 (Hamilton's Itinerarium, Albert Bushnell Hart, ed., St. Louis, 1907, p. 4), speaks of having a "curiosity to see a thing [ginseng] which had been so famous." David MacPherson, Annals of Commerce, London, 1805, 3:572 gives among the articles exported in 1770 from the American colonies—which he regards as including Newfoundland, Bahama, and Bermuda—74,604 lbs. of ginseng valued at £1243.8s.

[3] One was built in Danvers, Mass., in 1755, but was never used. J. W. Hanson, History of the Town of Danvers, from its early settlement to the year 1848. Danvers, 1848. George Henry Preble, Notes on Early Ship-building in Massachusetts, communicated to the New England Historical and Genealogical Register, 1871, p. 17.

Another influence leading to American commerce with China was the development of shipping in the colonies. The West Indian trade, the fisheries, and a commerce with Portugal and the Mediterranean,[4] had been important means of support to the Northern Colonies, and had raised up a hardy race of sailors and small merchant firms.[5] The spirit of adventure needed in the initiation of long voyages to China had received cultivation from piracy. For instance, in the last years of the seventeenth century the waters north of Madagascar were infested with a band of marauders who fitted out their ships, obtained their supplies, and often spent their ill-gotten gains in Rhode Island, Massachusetts, New York, and the Carolinas.[6] A letter of 1696[7] said of them, "All the ships that are now out are from New England, except Tew from New York, and Want from Carolina."[8] The privateering of the Revolution had an even greater influence. Craft bearing letters of marque from the colonies swarmed the seas. Large fortunes were accumulated, a surplus shipping, too large for the coasting trade, was built, a knowledge of distant seas was acquired, and an adventurous spirit was

---

[4] Charles E. Trow, Old Shipmasters of Salem, New York and London, 1905. p. 48.

[5] Log books in the Essex Institute, Salem, for this period, show something of the extent of the trade. See also G. F. Chever, Some Remarks on the Commerce of Salem, from 1626 to 1740, with a sketch of Philip English, a merchant in Salem from about 1670 to about 1733-1734. Hist. Cols. of Essex Instit. 1 : 67.

[6] Gertrude Selwyn Kimball, The East India Trade of Providence, Providence, 1896, p. 3, quotes the Governor of New York from the N. Y. Col. Docs. Vol. 4, p. 306, to the effect, that "I find that those Pirates that have given the greatest disturbance in the East Indies and the Red Sea, have either been fitted from New York or Rhode Island, and manned from New York." See also Paullin, Diplomatic Negotiations of American Naval Officers. Baltimore, 1912, pp. 154-156.

[7] T. South to the Lord Justices of Ireland, from Dublin, Aug. 15, 1696. Calendar of State Papers, Colonial Series, America and West Indies. May 15, 1696—Oct. 31, 1697. J. W. Fortescue, ed., London, 1904.

[8] A letter to the East India Company from Bombay, Ibid. 1697-8, p. 363, says of the same band, "There is a nest of rogues in the Isle of St. Mary's [near Madagascar] . . . . where they are frequently supplied . . . . by ships from New York, New England, and the West Indies."

stimulated in sailors and merchants.[9] With the end of the war these were forced to seek other outlets.

Still another influence was the loss of the trade with the British West Indies. Before the Revolution the colonies had, of course, been included in the British colonial system. They had sent their provisions and lumber to the West Indies, had received in payment credit on England, and with this credit had secured the necessary old-world manufactures and supplies. Independence, by placing them outside the colonial system, made it necessary for them to look elsewhere for the investment of their commercial capital, and for the means of paying the bills owed by them to British merchants and manufacturers. As Phineas Bond wrote at the time[10]: "In the restricted state of American trade it is natural for men of enterprise to engage in such speculations as are open to them, and which afford a prospect of profit."

But independence and withdrawal from the colonial system, while shutting the door of the West Indies, had opened that to Asia and the East Indies. For nearly a century the East India Company had held a monopoly on the British trade in the entire hemisphere from the Cape of Good Hope eastward to the Straits of Magellan.[11] After the treaty of peace, this, of course, ceased to be binding on the new nation, and it would have been strange

---

[9] Trow, Old Shipmasters of Salem, pp. xx-xxiv. Charles S. Osgood and H. M. Batchelder, Historical Sketch of Salem, 1626-1879, Salem, 1879, p. 137. H. W. S. Cleveland, Voyages of a Merchant Navigator of the Days that are past. Compiled from the Journals and Letters of the Late Richard J. Cleveland, New York, 1886, p. 6. Horace S. Lyman, History of Oregon: The Growth of an American State, 4v, New York, 1903, 2:87, says that Captain John Kendrick of the "Columbia" had commanded a privateer. The log books of some of the privateers exist in the Essex Institute in Salem.

[10] Letter to Lord Carmarthen, July 2, 1787. Letters of Phineas Bond, British Consul at Philadelphia, to the Foreign Office of Great Britain, 1787, 1788, 1789. Edited by the Historical Manuscripts Committee of the American Historical Association. In Annual Rep. of Am. Hist. Ass'n. for 1896. Vol. I, pp. 513-659. p. 540.

[11] Great Britain, The Statutes at Large, London, 1763 et seq. 3:738; 9 and 10 Wil. III (1698) c. 44, sec. 81, give this grant, and place as a penalty, forfeiture of ship and cargo.

indeed if advantage had not been taken of the opportunity thus given.[12]

In the light of these causes we are not surprised to find in the United States widespread movements in 1783 and the years immediately following to take advantage of the China trade. In 1783 Salem and Boston began to agitate the matter,[13] and Boston merchants had already planned a voyage. In 1784 such a venture seems to have been planned in Connecticut, and was defeated only because the amount of state aid asked was larger than the sturdy yeomen would grant.[14] In 1784 a Boston vessel got as far as the Cape of Good Hope, and returned with a cargo of fresh teas purchased there from the British.[15]

It was in this same year, 1784, that an American ship first reached China. In the latter part of November, 1783, Robert Morris wrote to Jay, "I am sending some ships to China in order to encourage others in the adventurous pursuits of commerce."[16] This probably referred to the "Empress of China," John Green, Master.[17] Robert Morris and Daniel Parker and Company of New York joined in fitting her out,[18] and engaged as supercargo

---

[12] Fitzsimmons, in a speech on the tariff, Apr. 16, 1789, describes the situation quite exactly. Thomas Hart Benton, Abridgment of the Debates of Congress from 1769 to 1856, 1857-1861. New York. 1842.

[13] Joseph B. Felt, Annals of Salem. 2 v. Salem. 1845-9. 2: 285, 291.

[14] William B. Weeden, Economic and Social History of New England, 1620-1789. 2 v. Boston and New York. 1890. 2: 821. He quotes from the Connecticut Archives, a manuscript collection at Hartford.

[15] This was advertised for sale in July, 1784. Hamilton Andrews Hill, The Trade and Commerce of Boston, 1630 to 1890, in Justin Winsor, Memorial History of Boston. Boston. 1881. 4: 203.

[16] Nov. 27, 1783. The Correspondence and Public Papers of John Jay, edited by Henry P. Johnston. New York and London. 1891. 3: 97. See also Ellis Paxson Oberholtzer, Robert Morris, Patriot and Financier, 1903, p. 222, and William Graham Sumner, The Financier and Finances of the American Revolution. 2 v. New York. 1892. 2: 162.

[17] This seems to have been universally believed at the time, and no one has ever questioned it. There seems to be no evidence which would lead one to doubt it.

[18] The Journals of Major Samuel Shaw, the first American Consul at Canton, edited, with a life of the author, by Josiah Quincy, Boston, 1847, give a full account of this voyage, and are reliable, since the author was the supercargo of the ship and wrote from his journals kept on the trip. The account of the voyage, unless otherwise indicated, is taken from him.

Samuel Shaw, a man of some education, who had seen honorable service as an officer in the Continental army.[19] The main part of the cargo was ginseng. The ship sailed February 22, 1784, protected by a sea letter granted by Congress.[20] She stopped at the Cape Verde Islands for water and repairs, rounded the Cape of Good Hope, and then steered a straight course for the Straits of Sunda.[21] Here she met a French ship and in company with her proceeded to China, anchoring at Whampoa, the harbor of Canton, August 28th. The Chinese after a little trouble learned to distinguish the Americans from the English, calling them "the New People."[22] The representatives of the various European nations welcomed them, and even the English were friendly and seemed anxious to forget the recent war. With the assistance of more experienced traders, specially the French, the Americans threaded their way safely through the unaccustomed maze of the Canton trade regulations, disposed of their ginseng and merchandise to advantage, and purchased a cargo of teas and China goods of various kinds. Returning, "The

---

[19] He was successively adjutant, captain, brigade major of artillery, and, finally, aide de camp to General Knox. Quincy's life of Shaw is good. Delano says of Shaw, "He was a man of fine talents and considerable cultivation." Amasa Delano, Narrative of Voyages and Travels in the Northern and Southern Hemispheres. Boston, 1818. p. 21.

[20] The Journals of the United States in Congress assembled [Confederation], Philadelphia, . . . 10:47. Similar letters were frequently granted later. For instance, to the "Canton," March 22, 1785 (10:97) and Jan. 2, 1786 (11:14); to the "Hope," Jan. 26, 1786 (11:17); to the "Columbia" and "Lady Washington," Sept. 24, 1787 (12:144, 145); and to the "General Washington," Oct. 25, 1787 (12:217).

[21] Most accounts of the voyage are taken from Shaw's Journal, but garbled ones are given in Robert Waln, Jr., Life of Robert Morris, in John Sanderson, Biography of the Signers of the Declaration of Independence, Philadelphia, 1823, p. 368, which is quoted by Sumner, Financier and Finances of the American Revolution, 2:162. It calls the ship "The Empress" and says that it was the first attempt to make an out of season passage to China by going around the south cape of New Holland. A cursory examination of Shaw's Journals will show that Waln was correct only in the year of the voyage, both the name of the ship and the course being wrong. He may have confused it with the voyage of the "Alliance."

[22] For the first year, to avoid extra presents demanded of nations opening trade, the Americans were reported to the Hoppo, or customs collector, as English.

Empress of China" sailed in company with some Dutch ships for a distance, touched at the Cape of Good Hope, and arrived safely in New York May 10th, 1785. The final profit of the voyage was estimated at $30,727, or about twenty-five per cent. on the capital invested.[23]

The news of this successful voyage created much interest and added incentive to the plans which were already projected. Shaw reported the result of the voyage to Jay, the Minister of Foreign Affairs, and received soon afterward by order of Congress a reply telling of that body's "peculiar satisfaction in the successful issue of this first effort of the citizens of America to establish a direct trade with China."[24] Long accounts of the voyage were published in the New York papers and copied in the different commercial cities.[25] In Boston, plans were soon under way for building and fitting out a ship for the East India trade[26] in which "any citizen who wished to become interested" might purchase a share for $300. Robert Morris, satisfied with the result of his first venture, continued his investments.[27] He bought from Shaw and Randall a cargo of teas which they had shipped home in the "Pallas," and talked of engaging the two for another voyage.[28]

---

[23] Another brief summary of the voyage is in John Austin Stevens, Progress of New York in a Century, 1776-1876. New York, 1876. p. 45.

[24] Shaw's Journals, Appendix, p. 337, gives Shaw's letter (May 19, 1785) and Jay's reply (June 23, 1785). The report of the committee is in the Continental Congress Reports of Committees (Ms. in Library of Congress). It was read June 9, 1785. It is also mentioned in the Journal labeled Reports of Coms. (Ms. in Library of Congress).

[25] A column and a quarter was given to it in the Providence Gazette, May 28, 1785.

[26] Hill, Trade and Commerce of Boston, p. 81, quotes from the Independent Chronicle for June 23, 1785, to that effect.

[27] Robert Morris to Jay, May 19, 1785. Jay's Corres. and Public Papers, 3 : 143.

[28] Shaw's Journals, p. 218. Morris may have sent the "Empress" a second time. A letter to which there is no author nor name of person addressed, but with the date New York, Nov. 3, 1786, in Letters Written to the British Government by agents from America, labeled America and England, 1783-1791, Ms. transcripts in Lenox Library, mentions the "Empress of China" as having arrived June 6, 1786, from Canton after a voyage of thirteen months. This leaves such a short time for her to unload, load, and clear from New York after her first voyage that it seems more likely that the date is wrong. It should probably be 1785.

In 1787 he helped to send out the "Alliance," Thomas Reid, master, on a voyage which attracted much attention at the time, both because of the size of the ship and because of the course followed.[29] An old frigate, she was much larger than the ordinary American Indiaman. She left Philadelphia June, 1787, and returned September 19, 1788, with a cargo said to have been worth half a million dollars. She has been popularly reported to have sailed with no chart but a map of the world, without letting go her anchor ropes from the time she left Philadelphia until she reached Canton, and to have been the first American ship to go to China by way of the south cape of Australia![30] Her return temporarily saved Robert Morris from bankruptcy.[31]

Still other voyages were undertaken. Stewart Deane, an old privateersman, after consulting with Captain Green of the "Empress of China," sailed for Canton in the latter part of December, 1785, in a sloop of eighty-four tons. So small was the vessel that when it reached China it was mistaken for a tender to a larger ship.[32] Shaw went out again from New York in February, 1786, as supercargo of the ship "Hope," James Magee, master, and carried with him a commission from Congress as Consul at Canton. This office was rather an empty honor; the occupant was not "entitled to receive any salary, fees, or emoluments," but merely hoisted a flag, did a little routine business, and was looked upon by the Chinese as a head

---

[29] For accounts and mention of this voyage see Letters of Phineas Bond, Oct. 2, 1788, p. 578. Waln. Life of Robert Morris in Sanderson, Biography of the Signers of the Declaration of Independence, Philadelphia, 1823, 5: 368. (He was copied with slight changes by Oberholtzer, Robert Morris, p. 224.) Parliamentary Papers, 1821, 7: 122; C. Dixon, Voyage Round the World. More particularly to the Northwest Coast of America. London, 1789. p. 298; Freeman Hunt, The Library of Commerce, Practical, Historical, and Theoretical. New York, 1845. 1: 118; Abraham Ritter, Philadelphia and her Merchants as constituted Fifty to Seventy years ago. Philadelphia, 1860.

[30] Her course is certain.

[31] Sumner, Financier and Finances of the Am. Rev., 2: 227. He quotes for his authority a letter of one of the English agents in the United States to Lord Dorchester, 1788, given in Canadian Archives, 1890. 104.

[32] Timothy Pitkin, A Statistical View of the Commerce of the United States of America. New Haven, 1835. p. 245.

merchant. It was the first American Consulate beyond the Cape of Good Hope, however, and was the only one in China until after 1844.[33]

On the return passage of her first voyage the "Empress of China" had found the "Grand Turk" of Salem at the Cape of Good Hope, evidence that the enterprising merchants of the witch town were already looking toward the East. It was this same vessel which Elias H. Derby, a merchant who had made a large fortune in privateering during the Revolution, sent to Canton a few months later, the first Salem ship to visit that port.[34] Providence, too, was caught by the China fever. Her merchants, cut off from the West Indies, had been looking for fresh fields for investment, and the news of the profits to be made in the Canton trade soon roused them. John Brown, a West Indies merchant, and the senior partner of Brown and Francis, was the first to make the venture. His ship, the "General Washington," Captain Dennison, sailed December 27, 1787, stopping first at Pondicherry and Madras,[35] and going thence to Canton.[36] Returning she reached America July 4, 1789. Although the venture was not as profitable as had been hoped, it was the

---

[33] Shaw's Journals, pp. 218-222. Shaw held the office until 1794. His successors were Samuel Snow (Quincy's Life of Shaw, p. 125), Edward Carrington, B. C. Wilcocks, Richard R. Thompson, John H. Grosvenor, P. W. Snow, Paul S. Forbes (Consular letters, Canton). There were frequent gaps, often of years, when the office was occupied by a vice consul or a consular agent.

[34] She sailed from Salem January 3, 1786. Robert S. Rantoul, the Port of Salem, in Hist'l Cols. of the Essex Instit., 10: 55. Paullin, Diplomatic Negotiations of American Naval Officers, p. 161.

[35] This course was probably taken because of the influence of an Englishman who had spent seven years in India and who went along on the voyage. He is mentioned in a letter of John Brown to his brother, August, 1787. Moses Brown Papers, 6: 11, quoted in Miss Kimball's notes.

[36] The log book of the "General Washington" is in the Brown and Ives Papers, in the John Carter Brown Library of American History in Providence, and is above the average manuscript log for fullness of detail. William B. Weeden, Early Oriental Commerce in Providence, in Mass. Hist'l Soc. Proceedings, 3d Series, 1:236-278, Boston, 1908, pp. 236-240, tells of it, and Gertrude Selwyn Kimball, The East India Trade of Providence, Providence, 1896, p. 4, gives an account of it. Shaw's Journals, p. 318, tells of the return voyage.

beginning of a series of voyages from Providence which continued for many years.

The Canton trade thus started had become firmly established by the year 1790. Merely running over such names of the ships engaged in it as have come down to us gives us some idea of its extent. There were the "Asia," Captain Barry, and the "Canton," Captain Truxton, whose voyages were not very successful,[37] the "Jenny," Captain Thompson,[38] and the brig "Eleonora," Captain Metcalf,[39] both of New York, at Canton in 1788; the "Massachusetts" of Boston, a large Indiaman built for Samuel Shaw in 1789, said to have been the largest ship built up to that time in America, sold to the Danish East India Company at Canton on its first voyage[40]; and the "Astrea" of Salem, James Magee, master, and Thomas H. Perkins, supercargo.[41]

The American trade with China was from the first compelled to fit into the Canton commercial system. This latter was so peculiar, and yet so vital in all early relations with China that a somewhat detailed description of it is essential to a full appreciation of the succeeding sixty years of American intercourse with the Middle Kingdom.

What first impressed the traveller in Canton was that commerce was carried on "under circumstances peculiar to itself; it [was] secured by no commercial treaties, [and] regulated by no stipulated rules."[42] Freed from all treaty restrictions and diplomatic interference, the organization formed was the result of a curious combination of Chinese contempt for foreigners, of fear of their naval prowess, of desire for their trade, and of official greed and corruption. Until modern times the Middle Kingdom had been largely shut off from the rest of the world by the vast mountain system on her west and by the sea on her

[37] Shaw's Journals, pp. 295-296.

[38] Ibid.

[39] Ibid., p. 297.

[40] Delano, Voyages, pp. 21-25.

[41] Journal of Brig "Astrea" to China. Ms. in Essex Institute, Salem.

[42] Edmund Roberts, Embassy to the Eastern Courts of Cochin-China, Siam, and Muscat, in the U. S. Sloop of War Peacock . . . . during the years 1832, 3, 4. New York, 1837, p. 126.

east. Her people had not come into intimate contact with their equals in civilization until the nineteenth century. Their foreign relations had been almost exclusively with tribes of inferior culture, a culture which at its best was a crude copy of a Chinese original.

Although conquered at times, the sons of Han had always assimilated their victors. The entire course of their history had bred a profound contempt for all foreigners, and had led them to apply to the latter the term "barbarian." It is not surprising, therefore, that early modern relations with the Occident were hampered by the conviction that foreigners were mercenary, interested only in trade, and beneath the contempt of the Chinese gentry and literati; that the China trade was necessary to their very existence[43]; that they did not have the ability to learn to read or to speak Chinese; and that all embassies sent to Peking came merely to bear tribute.[44] This contempt was mingled with an undercurrent of annoyance. The Manchus were not a naval power; they were, in fact, utterly impotent on the sea,[45] and after the piratical acts of many of the early European adventurers, especially of the Portuguese, they felt it wise to limit western merchants to as few ports as possible and to police them carefully while there, "lest they come and make trouble." Only the strong commercial interests of the Chinese prevented the entire prohibition of trade.

The Chinese officials were lovers of money, and where trade was once permitted their greed led to the imposition of as many duties and exactions as possible, and to a venality so great that by judicious bribery these same duties could be evaded and many port regulations disregarded with impunity.

---

[43] An anonymous memorial to the Emperor said: "Inquiries have served to show that the foreigners, if deprived for several days of the tea and rhubarb of China, are afflicted with dimness of sight and constipation of the bowels, to such a degree that life is endangered." The Chinese Repository, Canton, 1822-1851. 7:311.

[44] E. J. Eitel, Europe in China, The History of Hongkong from the beginning to the year 1882, London and Hongkong, 1895, p. 12, gives a good summary of the feeling as a whole. See too Chinese Repository, passim, for official edicts on the China trade.

[45] This their trouble with Koxinga in Formosa had shown them long before.

When the "Empress of China" had reached Canton, trade had been strictly confined to that port for nearly a generation. The Portuguese colony at Macao, at the mouth of the Pearl River, and the factories at Canton were the only spots where residence was permitted.[46] The existing regulations had some of them been in force since 1720, some since 1760.[47] The central institution was the "co-hong," through which all trading was done, and through which the government communicated with the foreigners. This body dated from an imperial edict of 1720 which substituted it for a single "Emperor's Merchant."[48] It had been dissolved in 1771 only to be reinstated in 1782, and was in full working order when the first American arrived. This *Hong Sheung* or *Yeung Hong Sheung* ("Foreign Associated Merchants") known more commonly by the pidgin-English corruption, "Co-hong,"[49] was a loose monopoly established by the imperial government expressly for the control of the foreign trade at Canton. It was composed of a varying number of "hong merchants." Theoretically thirteen in number, they were usually fewer, and sometimes dwindled to six.[50] Far from being a stock company, each merchant did business independently of the others, enjoyed his own profits, and, legally at least, bore his own losses. They acted together merely for the control of foreigners and the enforcement of trade regulations. There later grew up a mutual responsibility for debts, but this seems not to have been an integral part of the system, and was sanctioned only by special arrangement after each new failure.[51] With true

[46] There had been a little trade at Ningpo in 1755 but soon after that an imperial edict restricted all foreign commerce to Canton. Williams, History of China, p. 96.

[47] William C. Hunter, The Fan Kwae in Canton before Treaty Days, 1825-1844, pp. 28, 34. Eitel, Eur. in China, p. 5.

[48] Hunter, Fan Kwae in Canton, pp. 28, 34; Eitel, Eur. in China, p. 8.

[49] Samuel Wells Williams, Establishment of American trade at Canton, in China Review, 5: 152-164, p. 155.

[50] Memorial to Emperor, Sept., 1837, Ch. Rep., 6: 292-296. John Francis Davis, China, 2 v., London, 1857, 1: 98.

[51] C. Toogood Downing, The Stranger in China, or the Fan Qui's visit to the Celestial Empire in 1836-7. 2 v., Philadelphia, 1838, 2: 123-133. In 1830 an attempt was made to abolish it entirely which succeeded for at least a few years. Responsibility was renewed in 1838 in a special case. Davis, China, 1: 127-128.

Chinese astuteness, however, these debts of bankrupt hongs when guaranteed were paid by a special tax on the trade.[52]

The theory of the hong organization was that although the barbarians were not worthy of direct communication with government officials they were a troublesome set, and needed close attention and restraint. To the co-hong, then, was given the complete control of all foreigners, their persons, their property, their servants, and their trade, and in return it was held responsible for their actions. The monopoly relaxed as time went on, and a large body of "outside merchants" grew up, each of whom, although legally allowed to furnish only those things needed for the personal use of the foreigners, paid some hong merchant for the privilege of unrestricted trade.[53] A position on the co-hong was purchased from the government, frequently at a high price; but the place was not in every respect an enviable one. The unfortunate merchant was subject to heavy assessments and official "squeezes" and at any time might be held responsible to the extent of his life for chance disorders among foreigners. He could not retire from his position without special permission, a favor which at least must be purchased and might be entirely refused.[54] The commercial character of members of the co-hong seems, on the whole, to have been high, and although bankruptcies were fairly frequent, testimonies from Americans and others to the honesty of the body are quite numerous. Howqua, for example, the most famous of those engaged in the American trade, bore an unimpeachable name for honesty and philanthropy. The system was in general an effective way of handling the trade as long as it was limited to Canton and before government relations began.[55] When the treaties

---

[52] Chinese Rep., 6: 292-296.

[53] Hunter, Fan Kwae in Canton, p. 35. Also evidence of Abel Coffin, Mar. 20, 1830, quoted in John Phipps. A Practical Treatise on the China and Eastern Trade. Calcutta, 1835, p. 310.

[54] Hunter, Fan Kwae in Canton, p. 36. Downing, The Stranger in China, 2: 123-133.

[55] "I never saw in this country such a high average of fair dealing as there." Letters and Recollections of John Murray Forbes. Boston and New York, 1899, 1: 86. Hunter, Fan Kwae at Canton, p. 97, pays a high tribute to the system and to the honesty of the merchants.

which followed the first British-Chinese war were signed, it had outlived its usefulness and rightly came to an end.

The co-hong was the central point in the commercial organization, but there were, in addition, many regulations which grew up as custom or which were formally enacted from time to time. When a ship arrived at the mouth of the Pearl River, a pilot took it in charge and brought it to Macao. Here an official permit was secured which permitted it to go to Whampoa, and a licensed pilot was taken on board. This latter, with the aid of the assistant pilot, brought the ship past the Bocca Tigris, or mouth of the river, and the first and second bars, and up to Whampoa. This anchorage, twelve miles below Canton, was as far as foreign ships could go, and here they were unloaded and loaded.[56] Before trade could be opened, however, the ship had to be secured by one of the hong merchants, who guaranteed its good behavior and the payment of its duties, and through whom in return most of its sales and purchases were usually made. It had also to obtain a *comprador* to furnish it supplies, and a *linguist* who for a percentage of the duties, transacted all the business with the custom house and with the various government officials. Then the vessel had to be measured by the deputies of the *Hoppo,* or superintendent of customs, the ship's extra tackle, overhall rigging, stores, and repair casks, must be put in a building or *banksall* on the shore,[57] a declaration made that no opium was on board, and a permit (*chop*) obtained for unloading the cargo. During the unloading and the loading, which was done by means of *chop* or *licensed* boats running

[56] John Robert Morrison, A Chinese Commercial Guide, Consisting of a Collection of Details respecting Foreign Trade in China, Canton, 1834. Captain Benjamin Hodges in 1789 paid $15 for the pilot to Macao, $40 for the pilot from Whampoa through the mouth of the river. Journal and Log of the Brig William and Henry from Salem, Mass., to Canton, Isle of France, and Salem. 1788-1790. Benjamin Hodges, Master. MS. The pilot expenses of the "Ann and Hope" in 1801 were; expenses at Macao, $9.25, for pilot inwards, $44, for boat at Macao, $4, for boats to tow ships over the second bar and boats stationed there, $14, for pilot outward, $56, for the attendance of six boats at the second bar, $6, for cumshaw (fee) to pilot outward, $2. Disbursements [of "Ann and Hope"] while on their voyage to London and Canton, Christopher Bentley, Master. MS.

[57] This custom fell into disuse in later years.

between Canton and Whampoa, the ship was watched by customs officials to prevent smuggling. Just before she sailed, a *grand chop,* or permission to leave, had to be obtained from the Hoppo.[58]

The duties and port charges were often heavy, and were for the most part uncertain and determined by custom. No table can be given, for no definite one was ever established, or at least, made known to foreigners.[59] There were both import and export duties, the former paid by the foreigner, the latter by the native merchant. In addition there were measurement duties, varying with the size of the ship,[60] a cumshaw tax, which was originally the sum of a number of extra-legal fees and percentages given to different officials, and was later transformed into a regular sum paid to the imperial custom house,[61] and pilots', linguists', and compradors' fees.[62] The last four were the same for all ships, and in 1832-3 amounted to $2,573 per ship.[63] The measurement and cumshaw taxes were remitted on ships importing rice.[64]

Various restrictions were placed on trade. No ships were admitted without a cargo of some sort aside from specie.[65] The importation of opium, the exportation of bullion except by special permit, and of large amounts of rice,[66] and any exportation of sycee, or of metallic manufactures, were forbidden. Salt peter could be imported only for the government.[67] No vessels of war could pass beyond the Bocca Tigris, nor could they even anchor off the coast, unless they came as convoys. Smuggling,

---

[58] The facts in this paragraph are to be found in W. W. Wood, Sketches of China with Illustrations from Original Drawings, Philadelphia, 1830, pp. 213-217, Morrison, Chinese Commercial guide, pp. 9-18, Roberts, Embassy to Eastern Courts, p. 126, Shaw, Journals, pp. 173-178, Hunter, Fan Kwae at Canton, p. 51, and the East India Trader's Complete Guide, London, 1825, p. 453. William Milburn, Oriental Commerce.

[59] Consular Letters, Canton, III.

[60] In 1832-3 it was $650 to $3000. Roberts, Embassy to En. Courts, p. 126.

[61] Morrison, Chinese Commercial Guide, p. 18.

[62] Ibid.

[63] Roberts, Embassy to Eastern Courts, p. 126.

[64] Ibid., p. 126, and Evidence of Abel Coffin, Parl. Papers, 1830, 5: 122.

[65] Snow to Secretary of State, Jan. 24, 1801, Consular Letters, Canton, I.

[66] Morrison, Chinese Com'l Guide, p. 18.

[67] Morrison, Chinese Com'l Guide, p. 18.

of course, was prohibited, and to prevent it, vessels were ordered to come immediately to Whampoa and not to linger around the coast.[68]

In addition to the regulations which had to do primarily with shipping, another series concerned the foreign residents of China. Here the Chinese attitude towards the barbarians was even more clearly manifested. They were to be held at arms' length, to be segregated and closely watched, and to be tolerated only as long as was necessary. Unsupported and unprotected by their home governments or by treaty rights, the foreigners depended for safety and justice entirely on the self-interest of the Chinese. No foreigner was allowed within the city wall of Canton, but was compelled to confine his ramblings to the suburbs, and his residence to the little plot of ground assigned to the foreign factories, or hongs. These buildings were rented from the hong merchants, and were situated on a plot of ground in the suburbs which extended a quarter of a mile along the north bank of the river.[69] Before them was a square, fenced off from the streets until the fire of 1822. The factories were thirteen in number, and were described by Cleveland[70] in 1798 as "handsome houses built in the European style, on the margin of the river. . . . They were generally of two stories, the lower being used as warehouses. They were whitewashed, and with their respective national flags displayed on a high staff above them, made a very pretty appearance." Between the factories

---

[68] Hunter, Fan Kwae in Canton, p. 28.

[69] Jacob Abbot, China and the English, New York, 1835, pp. 64-94, gives a vivid, although not very accurate, description, claiming to be that of an eye witness. Fitch W. Taylor, Flag Ship, or a Voyage Around the World in the U. S. Frigate Columbia, 2 v., New York, 1840, 2:170; W. S. W. Ruschenberger, A Voyage Around the World, Philadelphia, 1838, pp. 94 ff.; Richard J. Cleveland, A Narrative of Voyages and Commercial Enterprises, 2 v., Cambridge, Mass., 1842, 1:46, 47; J. W. Reynolds, Voyage of the United States Frigate Potomac, during the circumnavigation of the Globe in the years 1831, 1832, 1833, and 1834, New York, 1835, p. 336 et sqq.; Shaw's Journals, pp. 178-184, 345; Hunter, Bits of Old China, pp. 12-15; all contain descriptions of the factories by eye witnesses. Ch. Rep. 14:347, has a map, but the best are in Hunter, Fan Kwae in Canton, p. 25, and Morse, Internat. Rel. of Chin. Empire, p. 70.

[70] Cleveland, Voyages, 1:46, 47.

ran the narrow lanes known as Old China Street, New China Street, and Hog Lane, and behind them, Thirteen Factory Street, where were situated native shops to entice sailors when off duty.

Originally the foreigner was allowed to use even the limited area on which the factories were situated only during the trading season, and was required to spend the other months in the Portuguese colony at Macao.[71] No women were allowed in the factories, and any attempt to bring them there was the signal for trouble.[72] The number of servants was limited. All communications with the officials were required to be in the form of "respectful petitions," and to be made, not directly, but through the hong merchants. Riding on the river for pleasure was forbidden, and no one could visit the neighboring suburbs except on special days of the month. Linguists and compradors were employed as for the ships, and each foreigner had his good behavior "secured" to the magistrates by some hong merchant. In short, the "barbarians" were there by permission, a permission granted only by the "infinite compassion of the Son of Heaven."

As strict as these regulations seem, however, most of them were seldom enforced. Official corruption was well known, and tact and judicious bribery could secure immunity from all but the form of most of the rules. In time many others fell into disuse. In later years smuggling became extensive. Vessels anchored at Lintin outside the Bocca Tigris, loaded and unloaded by means of small boats and receiving ships, and avoided not only the port charges, but often some of the duties.[73] The foreigners stayed in the factories throughout the year; they could walk about the suburbs with impunity, and present petitions directly to the magistrates. The missionaries experienced but little serious interference in the study of the language, both written and spoken.[74] There were occasional spasms of reform

[71] Hunter, Fan Kwae at Canton, p. 80, speaks of the rule as still partly in force after 1830. It was broken as early as 1804 by Snow. Williams, Estab. of Am. Trade at Canton, p. 155. See also Shaw, Journals, pp. 173-175.

[72] Gideon Nye, The Morning of My Life in China, Canton, 1873, p. 9; Eitel, Eur. in China, p. 19; and Delano, Voyages, p. 540, tell of futile attempts to avoid the rule.

[73] William C. Hunter, Bits of Old China, London, 1885, pp. 1, 2.

[74] Ibid., pp. 1, 2, and Hunter, Fan Kwae at Canton, p. 60.

and renewed strictness it is true, as, for example, in 1834, when an edict of the governor placed new limitations on the number of servants,[75] and in 1839, when some new regulations were enacted.[76] But always the lapse of a few months saw the reins again loosened and business pursuing its former easy way.

---

[75] Nye, Morning of My Life in China, p. 73.
[76] Ch. Rep., 8:77-82.

CHAPTER II.

The Period of Expansion and of War, 1791-1814.

In the first flush of success Americans had felt that their trade with Canton was destined to expand indefinitely. It soon became apparent, however, that a limit would speedily be reached. The chief article of importation from China was tea, and its consumption in America was limited. Restrictions placed on its importation to Europe and the West Indies were practically prohibitive, and any extensive attempts to evade them were not to be thought of.[1]

Moreover, there was great difficulty in getting commodities with which to purchase cargoes in Canton. Through the centuries, Europeans had gone to China as to the rest of the East in quest of its teas and silks, while but few Western products could be found for which there was a return demand. The balance of trade had been met by heavy shipments of specie, a drain which had long been a cause of concern. Not until after 1825 or 1832 when China had cultivated her appetite for opium was the current of silver stemmed.

From the very first the Americans had faced this difficulty. For a time they had hoped that in ginseng they had found a product which would supply the need,[2] but before long it became apparent that the demand for the root was limited, and that specie must be exported extensively to make up the deficit.[3]

---

[1] Letters of Phineas Bond, p. 545, September 2, 1787.

[2] Shaw's Journals, pp. 229-236, 301, sqq.

[3] The following table, taken from Pitkin, Stat. View (1835 ed.) p. 303, and taken by him from the Register of the Treas., Washington (except for 1826-1832 which are from a Canton paper) show the proportion of specie exported to Canton from 1805 on.

YEAR	SPECIE	MDSE.	YEAR	SPECIE	BILLS ON ENGLAND	MDSE.
1805	$2,902,000	$2,653,818	1819	$7,414,000	$ 200,000	$2,603,151
1806	4,176,000	1,150,358	1820	6,297,000		1,888,000
1807	2,895,000	982,362	1821	2,995,000		2,397,795
1808	3,032,000	908,090	1822	5,125,000		3,067,795
1809	70,000	409,850	1823	6,292,840		2,046,549
1810	4.723,000	1,020,600	1824	4,096,000		2,364,000

Now, specie was of all commodities the one which the United States could least spare at that time. They had no silver or gold mines of importance. What coin came into the country was largely smuggled in from the Spanish colonies and was greatly needed to pay European bills. Specie was consequently hard to obtain for such luxuries as China goods, and when secured, much popular irritation was felt at its use for such a purpose.[4]

Unless these conditions could be changed, American trade with Canton would be extremely limited. Indeed, by 1790, it had already been overdone and had ceased to be as profitable as at the beginning.[5]

At about this time, however, two widely separated groups of events partially removed both of these hindrances and gave Chinese-American commerce an impetus which resulted in its rapid expansion. One, the European wars following the French Revolution, was still a few years off, the other, the opening of new sources of supply of goods for the China market, had just begun.

YEAR	SPECIE	MDSE.	YEAR	SPECIE	BILLS ON ENGLAND	MDSE.
1811	$2.330,000	$ 568,800	1825	$6,524,500		$2,437,525
1812	1,875,000	1,257,810	1826	5,725,200		2,056,101
1813	616,000	837,000	1827	1,841,168	$ 400,000	2,032,449
1814–15		451,000	1828	2,640,300	300,000	2,454,617
1816	1,922,000	605,000	1829	740,900	657,000	2,667,770
1817	4,545,000	1,055,600	1830	1,123,644	423,656	2,793,982
1818	5,601,000	1,475,828	1831	183,655	1,168,500	2,871,321
			1832	2,480,871	667,252	2,383,684
			1833	682,519	4,772,516	2,907,936

[4] The continued existence of this feeling is shown by a clipping from a Providence paper. In its issue of September 14, 1793, the United States Chronicle of that city attempted to mollify public opinion by telling of "fifty or sixty thousand dollars in specie," part of the proceeds of the "President Washington" and her cargo which had been sold at Calcutta in 1792, being deposited in the bank by Brown and Francis, "this sum being more specie than they had ever shipped to the Indies, although for six years past considerably engaged in the trade. It is expected it will operate in the minds of thinking people to do away with a prejudice against the trade, and convince them that it is our duty to encourage it, as being much more advantageous than for us to continue retailers of India goods for European merchants."

[5] Osgood and Batchelder, Salem, p. 138, say that the Salem-China trade seems to have been abandoned from 1790 to 1798.

The effect of the first of these on American commerce is too well known to require detailed treatment here. The United States were made the common carriers of Europe. The carefully erected trade barriers which had threatened to crush their commercial life were obliterated almost in a day. Large portions of the Continent and of the West Indies were thrown open to their goods. The result on the trade with China was to give a wider market for tea, and to provide specie and other commodities needed for cargoes to Canton. Between 1801 and 1811 from a fourth to a half of each year's imports of tea were re-exported from the United States. The embargo year of 1808 fell much below this average, but the following year made up for the deficit, since by drawing on the accumulated stocks Americans actually exported more tea than they imported.[6] In addition they took many cargoes directly from China to Europe without re-exportation.

The second group of events was of far less immediate importance in dollars and cents,[7] but in picturesqueness, in geographical and political results, and in territorial extent, it is of great interest. Moreover, it belonged so peculiarly to the China trade and had such important results that it demands a somewhat detailed treatment.

The dearth of specie impelled American merchants to seek some acceptable but less expensive substitute for the Canton market. Ginseng was wanted in only limited amounts, and the United States seemed for a time to have no other native product which would attract the Chinese fancy. Within a few years, however, there was found a demand for furs, for sandal wood, and for various products of the South Seas, and with this demand came the discovery and development of fresh sources of supply of these articles. The search for these classes of merchandise gave rise to important branches of the Canton trade which we must now describe.

The fur trade rose to meet a longstanding demand. Chinese houses were unheated, and warm dress was required to counter-

---

[6] Pitkin, Stat. View, ed. 1835, pp. 246-247.

[7] The importation of furs to Canton, for instance, was never more than fifteen per cent of our total imports into that port.

act the cold of winter. Woolens were scarcely ever used, and to provide the needed warmth the poor resorted to heavily padded clothes and the better classes to garments lined with fur.[8] When the "Empress of China" first reached Canton, some furs came through the Russians, and some from Europe and America through European traders.[9] The Americans were not long in learning of the demand,[10] and within a few years had opened up three sources of supply: the Northwest Coast of America, where various pelts, chiefly those from the sea otter, were obtained by barter from the Indians; the Falkland Islands, the islands off the West coast of South America, and the South Seas, where the fur seal was found; and the interior of North America, where the great fur-trading companies collected the pelts and shipped them from eastern ports, principally New York.

Of these sources, the first to acquire importance was the Northwest Coast of America. The pioneers were Russians, but for some reason they were slow to take advantage of their knowledge, and the secret did not penetrate to the rest of Europe.[11] A generation or so later, Captain Cook's sailors picked up some sea otter skins while on the Northwest Coast and on reaching Canton were surprised to have them sell for a sum which seemed fabulous. John Ledyard, an American who had been with the expedition, returned to the United States fired with the idea of taking advantage of the discovery. He approached Robert Morris and merchants in Boston, in New London, and in New York, but he failed to attain his object.

---

[8] Chinese Rep., 3 : 557.

[9] Ibid., and Speer, Oldest and Newest Empire, p. 412.

[10] George Bancroft said in describing the fur trade on the Northwest Coast: "At the time when the people of New England were the most ready to devote themselves to navigation, the prohibitory laws of many . . . . nations of Europe fettered commerce so much that they found the whole earth not too large for their activity." Letter to C. C. Perkins, Jan. 4, 1879, in C. C. Perkins, Memoir of James Perkins. In Proceedings of the Mass. Hist'l Society, 1 : 353-368, p. 359.

[11] In 1742 Bering's shipwrecked men killed the sea otter for food, carried about a thousand skins to Asia, and were given a large sum for them by Chinese merchants. A. C. Laut, Vikings of the Pacific. New York, 1905, p. 62. Hubert Howe Bancroft, History of the Northwest Coast, 2 v., San Francisco, 1884, 1 : 345.

He turned to Europe, and at Paris tried to enlist John Paul Jones, but failed when just on the point of success. He tried to cross Russia, perhaps intending to reach the Northwest Coast by that route, but failed again, and after returning lost his life in an expedition up the Nile.[12]

What John Ledyard had known, but by his too optimistic spirit had failed to induce people to believe, came unmistakably to the world in 1784 with the publication of Cook's Journals. The immediate effect of these was a great interest in the prospective trade. As Irving put it, "It was as if a new gold coast had been discovered. Individuals from various countries dashed into this lucrative traffic."[13] The first voyage was by the English, in April, 1785. The following year they and the Austrians and French were engaged in the trade.[14] The first voyage from the United States was not made until 1787. A company in Boston,[15] said to have originated in the house of Charles Bulfinch, in Bowdoin Square,[16] from discussions of Captain Cook's voyages,

---

[12] Jared Sparks, Travels and Adventures of John Ledyard, London, 1834, p. 175 et sqq. Milet Murrans. A Voyage Round the World in the years 1785, 1786, 1787, 1788, by J. F. G. de La Perouse, 3 v., London, 1798. 2: 287. There are other secondary accounts in Hill, Trade and Commerce of Boston, p. 82, and James Morton Callahan, American Relations in the Pacific and the Far East, 1784-1900, Baltimore, 1901. There seem to be no contemporary sources for this information, but the facts seem fairly well established.

[13] Washington Irving, Astoria, or Anecdotes of our Enterprise Beyond the Rocky Mountains. 2 v., Philadelphia, 1836. 1: 32.

[14] G. Dixon, Voyage Round the World. More Particularly to the Northwest Coast of America. London, 1789, pp. xvii-xix, 315. John Meares, Voyages Made in the Years 1788 and 1789 from China to the Northwest Coast of America. London, 1791, passim. Edward S. Meaney, Vancouver's Discovery of Puget Sound. New York, 1907, p. 26.

[15] Joseph Barrell, Samuel Brown, Charles Bulfinch, John Derby, Crowel Hatch, and John M. Pintard. Letter of Charles Bulfinch to William Cushing, December 1, 1816. In Bureau of Rolls and Library, Department of State, Washington.

[16] Bulfinch, Oreg. and Eldorado, p. 1. He should know, as he was related to the Charles Bulfinch of the company. Bancroft, Hist. of N. W. Coast, 1: 185, thinks there is no evidence of their having any knowledge of the operations of the English traders and that they got their ideas from Cook and Ledyard. Robert Greenhow, A History of Oregon

sent out two vessels, the "Columbia," Captain Kendrick, and the "Lady Washington," Captain Gray. They were instructed to stay on the coast two seasons, or longer if they thought best, and to send the sloop to Canton at the end of each season with part of the skins collected.[17] The "Lady Washington" reached the Northwest Coast in the summer of 1788 after touching at various points on the coast, and at Nootka found the English Captains Meares and Douglas. Here on September twenty-second the "Columbia" joined her, and here the two ships passed the winter. The spring and summer of 1789 were spent in trading along the coast, and at the close of the season all the furs were put on board the "Columbia," which then proceeded under Gray to Canton, sold its skins, took on a cargo of China goods, and returned to Boston by way of the Cape of Good Hope, arriving August, 1790, the first American vessel to circumnavigate the globe.[18] The adventurers were received with great ovations,[19] and although the profits did not come up to expectations,[20] the "Columbia" was again sent out. On this second voyage she made the discovery of the river that bears her name,[21] an event the full significance of which did not become apparent until the rise of the Oregon question in the next century. Captain Kendrick had meanwhile made two trips to China, in 1789[22] and in 1791 or

---

and California and the other Territories on the Northwest Coast of North America, Boston, 1844, p. 179, seems to think there was some causal connection between this and the earlier King George's Sound Company of London (the one which sent out Portlock and Dixon), but presents no evidence to substantiate it.

[17] Letter of Instruction of Joseph Barrell to the expedition, MS. in the Bureau of Rolls and Library, Department of State. It ended with the admonition, "We depend you will suffer insult and injury from none without showing that spirit which ever becomes a free and independent American."

[18] Bancroft, Hist. of N. W. Coast, 1 : 185-209, gives an account of the voyage. Up to June 14, 1789, he follows the diary of Robert Haswell, the best source for the voyage that he was able to find. (p. 186.)

[19] Meany, Vancouver's Discovery of Puget Sound, p. 34.

[20] Letter of Charles Bulfinch to William Cushing, Dec. 1, 1816.

[21] This was in May, 1792. Bancroft, Hist. of N. W. Coast, 1 : 260. He cites her manuscript log for this date.

[22] Ibid., 1 : 209.

1792.[23] His was a visionary disposition as was shown in his purchase of lands from the Indians.[24] His career was ended some time later on the Hawaiian Islands by accidental death.[25]

About a month after the first return of the "Columbia" to America, Joseph Ingraham, her former mate,[26] left Boston as master of the brigantine "Hope."[27] He was partly financed by the young Thomas H. Perkins, who had learned of the trade from the "Columbia" while at Canton in January of that year.[28] On his way out he touched at the Marquesas Islands, and a few days later sighted five islands which he did not find on his charts,

---

[23] A letter from him dated Macao, March 28, 1792, Consular Letters, Canton, I, shows that he was there at that date, and he probably arrived in the latter part of 1791, or very early in 1792.

[24] Bancroft, N. W. Coast, 1:253. He cites Hall J. Kelley, Disc. of N. W. Coast, where the deeds are copied.

[25] Delano, Voyages, pp. 399, 400, says that he was killed accidentally by a salute fired in his honor by an English commander. Foster, American Diplomacy in the Orient, Boston and New York, 1904, p. 99, says that he died in 1793, possibly copying from Robert Greenhow, A History of Oregon and California and the other Territories on the Northwest Coast of America, Boston, 1844, p. 228, where the same statement is made. Bancroft shows that this date is probably false (Hist. of N. W. Coast, 1:297) placing it in 1796, a conjecture given color by the fact that Vancouver found the "Washington" at Nootka Sept. 2, 1794. (George Vancouver. A Voyage of Discovery to the North Pacific Ocean and Round the World. 3 vols. London, 1798. 3:300.) His death was probably late in 1795 or very early in 1796, as on May 28, 1796, John Howell wrote from Manila in regard to settling up his estate. (MS. letter in State Dept., Washington.) This letter, which shows his estate $17,717 in debt to Howell, and his own report of March, 1792, which shows him $10,000 in debt, bear out what has been said about his visionary nature.

[26] Joseph Ingraham, Journal of the Voyage of the Brigantine Hope, from Boston to the North West Coast of America. 1790-1792. MS. in Library of Congress. Bancroft, Hist. of N. W. Coast, 1:252, says that he was mate of the "Lady Washington." Either Bancroft is in error, or Ingraham was mate on the latter vessel at an earlier date.

[27] He sailed Sept. 16, 1790. Ingraham, Voyage of Hope, Greenhow, pp. 226-228, and Callahan, p. 18; the last two of whom take their accounts from the manuscript journal, are where the accounts for the voyage are found. The first is to be preferred as a source.

[28] Cary (son-in-law of Perkins) in N. Eng. Hist. and Gen. Reg., 10:201-211.

and which he named and claimed for the United States.[29] He traded along the Northwest Coast during the summer, and sailed for Canton in the fall, arriving in November, 1791, during a temporary prohibition which the Chinese had laid on American ships.[30] In the spring of 1792, after some trouble over an attempted evasion of the prohibition, he returned to the Northwest Coast, and in the autumn went to the Hawaiian Islands, where in November the journal of his voyage ends.

The years following 1789 showed great growth in the American Northwest Coast trade. In October, 1790, there arrived in China the brig "Eleonora," Captain Metcalf, and the schooner "Polly," Captain Douglas, from the Northwest Coast, both American,[31] but of these we know little. In October, 1791, the "Margaret" left Boston with James Magee, a part owner of the "Hope,"[32] as master. On her arrival on the coast (in the spring of 1792) she found twenty-eight other ships there, of which six were American. For ten years, the number of American ships engaged in the trade continued to increase, until in 1801, the banner year, there were at least fourteen on the coast.[33] The

---

[29] Ibid., and Ingraham, Disc. of some Ids. in S. Pacific, Mass. Hist. Soc. Cols., 2:20-24. Some of these same islands were renamed and new ones were discovered by Joseph Roberts in the ship "Jefferson" early in 1793. Disc. and Desc. of Marquesas, Mass. Hist. Soc. Cols., 4:241.

[30] C. P. Claret Fleurier, Voyage Autour du Monde pendant les Annees 1790, 1791 et 1792, Paris, 6 vols., an. vi., 2:368, mentions the same suspension of the fur trade.

[31] Providence Gazette, Jan. 11, 1791, which cites Allen's New London Marine List, June 8, 1791.

[32] Ingraham, Voyage of Hope. The facts of the voyage are from the log of the "Margaret." MS. copy in Essex Institute, Salem. The inspiration of the voyage came from the "Columbia," which he had found at Canton in 1789 or 90. N. Eng. Hist. and Gen. Reg., 10:201-211.

[33] William Tufts, Account of Vessels in the Sea Otter Fur Trade on the Northwest Coast (which seems to be correct as far as it goes). With the addition of all such omissions as have been detected this shows two vessels on the Coast in 1788, one in 1789, two in 1790, five in 1791, seven in 1792, four in 1793, two in 1796, four in 1797, eight in 1799, six in 1800, fourteen in 1801, nine in 1802, seven in 1803, five in 1804, six in 1805, five in 1806, five in 1807, three in 1808. The list is probably very incomplete, for in 1816 William Sturgis wrote that he had been on the Coast with seventeen American ships. He does not say in what year he was there. Letter to Charles Morris, Aug. 22, 1816.

normal voyage was to leave the United States in the summer or early fall, and to arrive on the Northwest Coast in the spring. The vessels would then trade with the Indians from inlet to inlet along the fjord-broken coast, getting skins, preferably those of the rare sea-otter, in exchange for trinkets, knives, fire arms, blankets, cotton and woolen cloths, and other similar wares.[34] In the fall they would go to Canton, or if they had not yet obtained a cargo they would winter at the Hawaiian Islands and trade a second and even a third season on the Coast before going to China. Once there they would exchange their cargoes for teas and other goods, and return to the United States by way of the Cape of Good Hope. The voyages were, as a rule, very lucrative. The original outlay for the cargo was small, the furs for which it was exchanged sold at Canton at a large gain, and the teas and goods which the proceeds purchased brought another gain in the United States or Europe, thus giving three chances for profit. The voyages were full of risk and required experience, and the trade fell into the hands of a few large firms, the Perkins, the Lambs, Dorr and Sons, the Cooledges, the Lymans, the Sturgis family, all of Boston, D'Wolf of Bristol, and a few others. The merchants of Philadelphia, New York, and Providence, were for the most part not engaged in it.[35] Small traders occasionally ventured out but the dangers from shipwreck, and especially from the natives, were great, and only a firm with several ships could survive the losses incident to such accidents.[36]

---

[34] Bill of lading of the "Louisa" to the N. W. Coast, Oct. 5, 1826.

[35] Tufts' account of vessels in the sea otter trade gives the names of these firms. William Sturgis, The Northwest Fur Trade, in Hunt's Merchant Magazine, 14:532-537, gives the facts about the other ports. He was himself connected with the trade.

[36] Numerous examples of these accidents can be cited. The "Columbia" suffered the loss of three men from the Indians in 1791 (Extracts from the log of the ship "Margaret," commanded by Captain James Magee. Voyage to the North West Coast, 1791-1792. Copy MS. in Essex Institute. This may be the incident of which Fleurier heard when in Canton in November, 1791. Voyage Autour du Monde. 2:377). Vancouver found in Hawaii a survivor of the "Fair American," an American schooner manned by the younger Metcalf, that had been captured and had had its crew murdered by the natives in retaliation for punishment inflicted by the elder Metcalf for the murder of some of his men (Van-

About 1802 the trade to the Northwest Coast took on a new phase, trading and sealing voyages along the California coast. This was due partly to the increasing difficulty of obtaining skins by barter with the northern Indians, and partly to newly discovered sources of furs. In 1802 the "Lelia Byrd," Cleveland, master, coasted along California, trading for furs with the Spanish settlements.[37] In 1803 the "Alexander," Brown, master, and in 1804 the "Hazard"[38] and the "Lelia Byrd" under Shaler, Cleveland's partner,[39] did the same. It was largely illegal trade and ships engaged in it were in danger of capture and confiscation.[40] In 1803 the "O'Cain" of New York obtained Indian hunters from the Russians at Sitka and went south, hunting on shares.[41] In 1805 John D'Wolf, master of the "June," finding barter unsuccessful, determined to go to California, but sold his ship to the Russians before carrying out his plan.[42] In 1806

---

couver, Voyage, 2:135). In 1803 the ship "Boston," John Salter, Master, was attacked by the natives at Nootka Sound in revenge for a fancied insult, his vessel was captured, and all but two of the crew were murdered. (The Adventures of John Jewett, only survivor of the crew of the ship Boston, during a captivity of nearly three years among the Indians of Nootka Sound in Vancouver Island. Ed. by Robert Brown. London, 1896. Secondary accounts are in Bancroft, Hist. of N. W. Coast, 1:312, and in Meany, Vancouver's Discovery of Puget Sound, pp. 39-43.) In 1803 and 1804 the "Atahualpa" of Boston, Adams master, lost some men by an Indian attack (page 171 of Shaler [?] Journal of a Voyage Between China and the Northwestern Coast of America, made in 1804. In the American Register or General Repository, vol. 3 (1808) pp. 137-175).

[37] Cleveland, Voyages of a Merchant Navigator, and Cleveland, Voyages, 1:155-249.

[38] Herbert Howe Bancroft, History of California, 7 v., San Francisco, 1884-1890. 2:15.

[39] Shaler, Voyage between China and the Northwest Coast.

[40] "The Mercury" was captured and condemned in 1813, Bancroft, Hist. of Calif., 2:268. He quotes Mercury, Expediente de investigacion sabre Captura de la fragata American "Mercurio" 1813, MS. Several other ships were similarly treated in 1816. Ibid., 2:275.

[41] Bancroft, Hist. of N. W. Coast, 1:319. He quotes Boston on the N. W. Coast, MS., pp. 11-12.

[42] John D'Wolf, A Voyage to the North Pacific and a Journey through Siberia more than half a century ago, Cambridge, 1861; and Patterson, Narrative of Adventures and Sufferings, are accounts of the same voyage by two men who were on it.

the "O'Cain" returned, again obtained Indians from the Russians, and left for the California coast.[43] In 1810 and 1811 at least four vessels were there on the same mission[44] under Russian contract.

The relations between the Americans and Russians on the Northwest Coast were not confined to the California sealing voyages. In 1807 the Russians chartered an American vessel, the "Eclipse," to carry supplies from China to their settlements in Kamchatka and the Northwest Coast, a step made necessary by the Chinese rule which forbade the Czar's ships to come to Canton.[45] Part of the extensive plan of Astor was to supply the American settlements of the Czar with goods in exchange for furs.[46] More important, however, were the diplomatic troubles which arose.

In 1808 Count Romanzoff, Russian Minister of Foreign Affairs and of Commerce, complained to the American chargé d'affaires that American ships on the Northwest Coast, instead of trading with the Russian settlements, were carrying on a clandestine barter in fire arms with the natives to the danger of his majesty's subjects. Beyond a formal acknowledgment the Americans seem to have paid no attention to the note[47] and the matter was dropped for a time. In January, 1810, Daschkoff, the Russian chargé in Washington, took up the question again and proposed that the United States should order its citizens to confine their trade to the Russian factories and prohibit their carrying on any barter with the natives. The American Government,

[43] Ibid. D'Wolf calls it "Okain" and Patterson calls it "Ocain," but there is no reasonable doubt of its identity.

[44] Bancroft, Hist. of Calif., 2:93. He cites Albatross, Log Book of Voyage to N. W. Coast in 1809-1812, kept by William Gale, as authority. Some of the vessels were under the Winships.

[45] Archibald Campbell, A Voyage Round the World from 1806 to 1812. New York, 1817. The ship mentioned in Erasmus Doolittle, Sketches by a Traveller, Boston, 1830, in about 1809 or 1810 traded provisions to the Russians for skins.

[46] Am. Fur Trade, Hunt's Merc. Mag., 3:197-8. It is interesting to note that much the same thing was done for several years after 1815 for the British Northwest Fur Company by J. and T. H. Perkins of Boston to evade the monopoly of the East India Company. Reports of Committees, No. 43, 2 Sess., 24 Cong.

[47] American State Papers, Foreign Relations, Washington, 1858. 5:455.

however, evaded the question by asking the Russians to specify a definite line of demarcation, a step which the latter were not prepared to take.[48] On May 5th, the Secretary of State, in a note to Daschkoff, expressed his unwillingness to come to an agreement unless such a line were agreed upon. Even then a prohibition by the United States, said he, would be needless, for if the Indian tribes were under Russian jurisdiction the United States would surrender her merchants to the "penalties incurred by those who carry on a contraband trade in a foreign jurisdiction," and if they were independent, Russia could not prevent foreign trade with them unless it were in time of war and in contraband articles.[49] The negotiations thus closed at Washington, were reopened by Romanzoff at St. Petersburg, August 28th. He proposed to John Quincy Adams, the United States minister, that American ships be given the privilege of carrying furs from Russian posts on the Northwest Coast, and that in return the United States should agree not to furnish fire arms to the natives. When Adams asked for the boundaries which the Russians claimed, Romanzoff said that their charts showed that the entire coast as far south as the mouth of the Columbia River belonged to them. Adams seemed to feel that behind the plea for humanity there was an attempt to win an acknowledgment of the Russian claim for territory and courteously declined the offer. He reminded the minister that there was no real reciprocity in the proposed arrangement, as the Americans already had free access to the proffered trade, and that a prohibition could not be enforced on a coast which possessed neither ports nor custom houses.[50] After this reply, made early in October, 1810, the matter was dropped for eleven years.

Closely allied to the Northwest Coast trade were the fur-sealing voyages. They owed their origin to the same motives, the obtaining of pelts for the China market. They were quite distinct, however, being undertaken by different firms, and different towns. They went out from New London, New Haven, Stoning-

[48] Note of April 24, 1810. Ibid.

[49] Am. State Papers, Foreign Relations, 5: 455.

[50] Am. State Papers, For. Rel., 5: 455. Adams, Diary, 2: 151, 178. See a secondary account in Winsor, Narrative and Crit. Hist., 7: 510.

ton, New York, Philadelphia, Salem, and occasionally from Boston. They had for their object seal skins, not sea otter skins: they obtained them not by barter but by killing the seals themselves: and they were mostly in the Southern, not the Northern Hemisphere. The usual plan of the voyages was to spend one or two seasons sealing at the Falklands, Massafuero, or at some of the islands where seals were plentiful; then to proceed to Canton, to exchange their furs for China goods and then to return home by way of the Cape of Good Hope. One vessel often made several voyages, leaving part of its crew on the seal islands to collect skins until it should return.

These voyages had their origin almost simultaneously with those of the Northwest Coast. About 1785 or 1786 the ship "States," owned by Lady Hadley, was sent out on an experimental voyage. Thirteen thousand skins were taken, brought to New York, and shipped to Calcutta and Canton in the brig "Eleonora," about the time that Kendrick and Gray first left Boston.[51] In 1790, acting on the information obtained from this voyage, Elijah Austin of New Haven fitted out two vessels and sent them to the Falklands and South Georgia. One of these proceeded to Canton with its skins and returned by way of the Cape of Good Hope after a three years' absence.[52] In 1792, Magee obtained eleven thousand seal skins at St. Ambrose, and found sealing well established on the Falkland Islands. In March, 1793, Delano met at Canton the "Eliza," of New York, William R. Stewart, Master. She had come from Massafuero and had a cargo of thirty-eight thousand skins.[53] In February, 1793, the Macartney Mission found on the Island of Amsterdam a number of men who had been left there to collect skins while their vessel, a ship fitted out at the Isle of France and owned by Americans and French, should go to the North-

---

[51] The Diary of Mr. Ebenezer Townsend, Jr., the supercargo of the sealing ship "Neptune" on her voyage to the South Pacific and Canton; in papers of New Haven Colony Hist'l Society, vol. 4, New Haven, 1888. pp. 1-115. p. 3. Shaw, Journals, pp. 295-6, mentions her as in Macao early in 1788.

[52] Townsend, Diary, p. 3, et sqq.

[53] These sold for only $16,000, a very low price.

west Coast of America.[54] By 1804 the American sealers were causing trouble to the British in Australia, three having been there within a year.[55] These rather disconnected instances show the early origin and the broad scope of the sealing voyages.

The sealing industry, like the trade to the Northwest Coast, had a rapid growth and decline. Morrell estimated that from the Island of Massafuero alone three and a half million fur seals were taken and sold at Canton between 1793 and 1807.[56] Delano, writing after the commerce had declined, said that he had been at that same island when fourteen ships were sealing there.[57] The culmination of the industry was reached shortly after 1800. It was self-destructive. No attempt could be made to protect the seals, and a few years saw their almost complete destruction on islands where they had formerly been the most numerous.[58] To hasten the decline, competition had overstocked the Canton market and had brought the price below the profit point. By the opening of the War of 1812, the trade had nearly run its course.[59]

---

[54] George Staunton, An Authentic Account of an Embassy from the King of Great Britain to the Emperor of China. 2 v. London, 1798. 1 : 207. It is interesting to note that in 1802 some men were left for the same purpose by one of Perkins' ships on St. Paul, a neighboring island. Journal of Voyage from Salem to Sumatra and Manila in the ship "Active," George Nichols, master. 1801-1802. MS. in Essex Inst.

[55] Louis Becke and Walter Jeffery, The Americans in the South Seas. London, 1901, p. 237. Governor King of New South Wales wrote that "this is the third American vessel that has within the last twelve months been in the Straits and among the islands, procuring seal skins and oils for the China market."

[56] Benjamin Morrell, A Narrative of Four Voyages to the South Seas, etc., from the year 1822-1831. New York, 1832. p. 130.

[57] Delano, Voyages, p. 306.

[58] Doolittle, Sketches, p. 13. About 1809 or 1810 he found seals almost extinct on Massafuero. Charles W. Barnard, A Narrative of the Sufferings and Adventures of Captain Charles W. Barnard in a Voyage round the World during the years 1812, 1813, 1814, 1815, and 1816, New York, 1829, pp. 198-201. No seals were there in 1814, and the island was deserted. Barnard, however, had found some at the Falkland Islands some two years before. Ibid., p. 12.

[59] The last sealing voyage from New Haven, October 25th, 1815, et seq., was a failure. Thomas Rutherford Trowbridge, History of the Ancient Maritime Interests of New Haven, New Haven, 1882, p. 78. In 1828 we find as one reason urged for the sending out of an exploring

The third branch of the fur trade, that with its source in the interior of North America, cannot be as fully described as can the other two. Accurate statistics are wanting as to what pro-

---

expedition to the South Seas the discovery of new sources of supply for a trade that had formerly been so profitable. J. N. Reynolds, Address on the Subject of a Surveying and Exploring Expedition to the Pacific Ocean and the South Seas, New York, 1836.

The sealing voyages differed from those to the Northwest Coast in not being in the hands of a few large firms and in not sailing from a single port. They were sent out from Salem, Boston, Stonington, Hartford, New London, New Haven, New York, and Philadelphia, and as a rule were financed by quite a number of persons, each of whom invested a relatively small sum. New Haven entered the trade in 1790, but the best-known voyage from the port was that of the "Neptune" in 1796 to 1799, a venture owned by a number of persons in New Haven and Hartford. It brought to its owners what in those days was a large profit (Townsend, Diary. Another account in Trowbridge, Hist. of Ancient Maritime Interests of New Haven, says that Townsend, the chief owner, made $100,000 and his son, the supercargo, $50,000), and its success led to quite a number of other voyages in which persons from Hartford, Wethersfield, Middletown, East Haddam, Farmington, Derby, Litchfield, Milford, Branford, Stratford, Providence, and New London, were interested. (Trowbridge, Ancient Maritime Interests of New Haven, p. 76.) What was true of New Haven was probably true of the source of the capital for many other voyages.

Rough experiences and dangers were common in the trade. The rival ships' companies on the sealing islands must often have quarreled. (In 1802 there were 200 men on Massafuero, about 170 of whom belonged to no ship. A Concise Extract from the Sea Journal of William Moulton written on board the Onico, in a voyage from the Port of New London in Connecticut to Staten Land in the South Seas, etc. Utica, 1804, p. 98.) There were dangers, too, from the Spanish authorities, for sealing on His Catholic Majesty's islands was contraband; and vessels sometimes even tried smuggling into South American ports. (A journal of a Voyage from Salem to Massafuero . . . . to Canton and back to Salem on board the ship "Concord," Obed Myer, master, 1799-1802, MS. in Essex Institute, tells how the Spanish carried off to Valparaiso some of the men who were on the island. In 1803 Root was imprisoned for a term at Conception. Some time later a Spanish frigate ordered all sealers to leave the island in four months or be treated as prisoners of war. Pp. 156, 164 of Joel Root. Narrative of a Sealing and Trading Voyage in the Ship Huron from New Haven around the World. 1802-1806. In New Haven Hist'l Soc. Papers, Vol. 5, pp. 149-171. In November, 1805, Delano took on board five Americans belonging to Root who had been imprisoned by the Spanish for living on Spanish territory. Delano,

portion of the skins obtained through it were used at home, what sent to Europe, and what to Canton. Unlike the other two, it did not have its origin in the desire to supply the China market, and the Canton trade had but a minor part in it. At times, however, it was important, and it probably had fewer fluctuations than either of the other two branches.

The treaty of 1795 with England by allowing for the first time direct shipment of furs from Canada to the United States is said to have increased our consignments of inland furs to Canton.[60] It is probable that John Jacob Astor laid part of the foundation of his fortune by shipping his furs to China.[61] It is certain that his Astoria scheme had the China trade as its central point. The object of this famous project was to establish a depot on the Northwest Coast to which furs could be taken overland from inland trading posts, and from which trading voyages could be sent along the coast. Annual vessels were to be sent around Cape Horn to bring supplies to the depot, to collect the furs gathered there, take them to Canton, and to return around Africa with a cargo of teas, silks, and other China goods.[62] The enterprise was a total failure. The depot was founded, but the "Tonquin," the first supply ship sent out, came to grief with the natives[63]; Astor's partners sold out to the

---

Voyages, p. 509.) There was danger from shipwreck and danger from lawless mutineers and still more from lawless natives. (As in the case of the "Nautilus" which attempted to go to the Northwest Coast about 1797. The ship was driven back, refitted in Kamchatka, went to the Sandwich Islands, thence to Otaheite with the hope of going to Massafuero, but was driven back again by storms and finally had to go to New South Wales. William Smith, Journal of a Voyage in the Missionary Ship Duff . . . . 1796-1802. New York, 1813, pp. 110-124.)

[60] Bancroft, Hist. of N. W. Coast, 1 : 521.

[61] Ibid., and Walter Barrett, The Old Merchants of New York City, New York, 1870, 1 : 417, seem to imply this, and James Parton, Life of John Jacob Astor, New York, 1865, p. 49, distinctly says this, stating that he sent his first ship there about 1800.

[62] Letter of J. J. Astor to J. Q. Adams, Jan. 4, 1823, in Greenhow, Hist. of Oreg. and Calif., p. 439. See also on this Astoria project, Irving, Astoria, Bancroft, Hist. of N. W. Coast, 1 : 512 ff., and 2 : 136 ff., and Am. Fur Trade, in Hunt's Merc. Mag., 3 : 197-198.

[63] Edmund Fanning, Voyages to the South Seas, Indian and Pacific Oceans, etc., etc., New York, 1838, pp. 137-151.

British Northwest Fur Company, the fort was captured by the British, the "Beaver," sent out next after the "Tonquin," was forced to lie idle in Canton through the War of 1812, and the whole magnificent project went to pieces with great loss to its originator.

The development of fresh sources of furs was only one of the attempts to find a substitute for specie which were made in the years following 1790. Identical in motive with the fur trade was a long series of voyages to the South Seas which had as their object the securing of sandal wood, *beche de mer* and various other products of those regions.[64]

The first of these articles to play a part in the American-China commerce was sandal wood. Just how and when the trade in it started is uncertain. There is a story unsupported by other evidence, and almost certainly unauthentic, that one of Astor's early ships found it on the Hawaiian Islands, took it aboard for firewood, and on reaching Canton was surprised to learn its value.[65] Delano says that as early as 1790 some of it was brought to Canton from the Sandwich Islands, but that not being the valuable variety it was sold at a loss.[66] The first certain date is March 10, 1792, when Vancouver found on one of the Hawaiian Islands some men whom Kendrick had left

---

[64] *Beche de mer,* a kind of sea slug found on the shallow reefs in tropical seas, when cleaned and cured is much esteemed by the Chinese as food. (Descriptions of it are in William G. Dix, Wreck of the Glide, with recollections of the Fijis and of Wallis Island. New York and London. 1848. pp. 1-30.) Sandal wood is an aromatic wood from a small tree which grows in the tropics and sub-tropics, and is used extensively in China for cabinet work and for incense. (Chinese Rep., 2:469.) Other articles from the South Seas were brought in minor quantities, such as tortoise shell, edible birds' nests, mother of pearl, and sharks' fins. (Fanning, Voyages to the S. Seas, p. 155. Ruschenberger, Voyage round the World, p. 242.)

[65] Barrett, Old Merchants in New York City, 1:421. He says that the trade was kept secret for seventeen years, while we have evidence of others being engaged in it as early as 1792.

[66] Delano, Voyages, 399. This statement was made in 1801 and he says that he saw it brought there, so that the story seems authentic. He may refer to Kendrick's venture, but in this case he would be off a year in his reckoning.

to gather the wood. Kendrick was to return in 1793 and take the cargo to Canton.[67] From these various accounts it seems certain that the first American vessels to bring sandal wood to Canton were those engaged in the fur trade, and that it was discovered by them while stopping, as was their custom, at the Hawaiian Islands.

After the discovery of the wood on the Hawaiian Group, trade in it quickly developed. William H. Davis and Jonathan Winship of Boston began shipping it about 1793,[68] and later obtained exclusive privileges in it.[69] As the knowledge of its value spread, it was discovered on the Fiji Islands and various groups in the South Seas. As in the Hawaiian Islands, it was intimately connected with the fur trade and was taken to Canton by ships sent out primarily for sealing. In 1804 the brig "Union" of New York, failing to obtain a cargo of skins, went under English contract to the Fijis[70] for sandal wood, and although the captain and some of the men were murdered by the natives,[71] the ship seems to have completed its cargo and gone to Canton.[72] In 1806 those interested in the "Union" sent out a second ship, the "Hope," Captain Reuben Brumley, this time especially for the wood. On the vessel's arrival at the Fijis a contract was made with a chief for the collection of a cargo; the natives brought the wood down from the mountains and piled it on the beach ready for loading, and receiving in return trinkets of various kinds. When the "Hope" left, the chief promised to collect a second cargo to be ready in eighteen months, and the agreement was given the force of a monopoly by placing a taboo on the sale of wood to other ships in the meantime.[73] The "Ton-

---

[67] Vancouver, Voyages, 1:172, 173. Another account is in Greenhow, Hist. of Oreg. and Calif., p. 228.

[68] Delano, Voyages, p. 399.

[69] Niles, Weekly Register, Baltimore, 1811 et sqq. Americans at Sea, 18:418.

[70] Edmund Fanning, Voyages Round the World, p. 314.

[71] Smith, Journal of Missy. Ship Duff, p. 151.

[72] Four years before this the American ship "Duke," Captain Melon, had been captured by the natives and the crew murdered, but no record is given as to why she was there and we can only guess that it may have been for sandal wood. Ibid., p. 149.

[73] The journal of the first voyage is given in Fanning, Voyages to the South Seas, pp. 12-69.

quin" sailed from New York under the same captain June 15, 1808, having obtained special exemption from the embargo then existing in the United States, and found that the contract made with the "Hope" had been scrupulously observed. Earlier in the same year another American ship had been at the islands on the same mission and had been wrecked, for one of the survivors was picked up by the "Tonquin" and taken to Canton.[74] In May, 1810, the brig "Active" sailed from Salem for the Fiji Islands,[75] the first of a long series of similar voyages from that port.[76] The most prosperous years of the South Sea trade were after the War of 1812. It was then that *beche de mer* began to form a part of the cargoes, and the supply of sandal wood was not badly depleted before 1820. The two decades after 1790, however, saw its beginning and the marking out of the main lines for its development.

In addition to trips to the Northwest Coast of America and to the South Seas, the Canton ships took other roundabout routes, many of them opened by the European wars. A map of their voyages would make a network over most of the known globe. The customary route from America was to touch at the Cape Verde Islands, to round the Cape of Good Hope, and then either to keep east until just south of the Straits of Sunda, or to go north to Mauritius, which the French were making a great entrepot for Oriental shipping, and thence to the Straits of Sunda and Canton.[77] But this customary route was varied in many ways. The ships often touched at Bombay and Calcutta, at Batavia, at Manila, or went round "New Holland," stopping at times at Botany Bay. Again, some vessels would stop at Amsterdam, at Hamburg, at St. Petersburg, or at Leghorn, either carrying freight there on their return voyage, or touching

---

[74] The survivor was Patterson. He gives a narrative of it in A Narrative of Adventures and Sufferings of Samuel Patterson, Experienced in the Pacific Ocean, etc., Palmer, 1817, pp. 80 et seq.

[75] William Leavitt, Materials for the Hist. of Ship Bldg. in Salem, Hist. Cols. of Essex Instit., 7:211, also Osgood and Batchelder, Salem, pp. 169 et seq.

[76] Ibid.

[77] Delano, Voyages, pp. 200-211, and passim. Cleveland, Voyages of a Merchant Navigator, p. 34.

on their way home to unload cargoes of teas and to take on freight for America.[78]

The opportunities afforded by the European wars and by the fur and sandal wood trades would never have been fully seized had it not been for the efficiency and daring of the American merchant marine. When at Canton shortly after 1800,[79] Krusenstern remarked in wonder that the American vessels were "so admirably constructed that they sail better than many ships of war, . . . [and] . . . . the captains of some of them at Canton . . . . have made the voyage from thence to America and back again in ten months." The ships were small, few being of five hundred tons burden. The "Eliza," in which Sturgis first went to the Northwest Coast, was one hundred thirty-six tons,[80] and some of Cleveland's voyages were made in vessels of less than fifty tons.[81]

The efficiency of the ships lay largely in the ability of the men who manned them. The American crews were smaller than

---

[78] Typical examples of these are as follows: The "John Jay" of Providence, 1794-5, touched at Bombay to try to get a cargo of cotton for Canton. Kimball, E. India Trade of Providence, pp. 14-17. In 1797-8 the same ship touched at Batavia on its way out, and at Hamburg and St. Petersburg and Lisbon on its way back; and in 1800 it was instructed to round New Holland and touch at Botany Bay. Weeden, Early Oriental Commerce in Providence, pp. 242-253. There are manuscript logs preserved of the voyage of the ship "Perseverance" of Salem, Nathaniel Hawthorne (father of the author) master, to Batavia, Manila, Canton, and return in 1796-8; of the ship "Ann and Hope" of Providence, Benjamin Page, master, which rounded New Holland in 1799-1800; of the "Indus" to Canton in 1802-3, touching at Batavia on the way back; of the ship "Derby" of Salem, Dudley S. Pickman, master, in 1804-5, to Leghorn and Canton and return; of the ship "Eliza" of Salem, William Richardson, master, in 1805-7, to the Isle of France, Port Jackson (New Holland), Norfolk Island, New Zealand, Canton, and return; of the "Hunter" of Salem, 1809-10, to Sumatra and Canton. In Weeden, Early Oriental Commerce in Providence, pp. 261-266, mention is made of the voyage of the ship "Arthur" of Providence, September 26, 1807, to June 3, 1809, to Rio Janeiro, Cape Town, Isle of France, Canton and Providence.

[79] Krusenstern, Voyage round the World, 2: 332, 331.

[80] Loring, Memoir of Wm. Sturgis, in Proc. of Mass. Hist. Soc., 7: 420-433.

[81] Cleveland's Voyages.

those on English or European vessels, but were more orderly and intelligent.[82] They were for the most part American born and from good New England stock.[83] Boys from the best families would go to sea, and at a very early age would become commanders of ships. William Sturgis, for example, began his sailor's career at the age of sixteen. At seventeen he was chief mate, and at twenty he was master of a ship in the Northwest Coast Trade. The attraction was not the wages, for those were not high,[84] but was partly the chance for a career, for before the days of New England factories no greater opportunities were open to the young men of business ambition than the sea and commerce, and partly the privilege granted to the crews of many of the ships, especially those to the Northwest Coast, of trading on their private accounts.[85] The China trade is an illustration of what the American genius, to-day spending itself in manufactures and internal transportation and development, can accomplish when diverted to the sea.

---

[82] Evidence of J. Drummond, Parl. Papers, 1821, 7:210. Evidence of Joshua Bates, Parl. Papers, 1830, 6:365-380.

[83] There were some exceptions to this rule. Log Book of the "Ann and Hope," beginning Sept. 22, 1825, MS. in John Carter Brown Library. In 1825 she got some seamen at Amsterdam, nine of whom had foreign names. Journal of a voyage in the ship Herald from Salem to Rotterdam, Canton, and return, in 1804-1805, MS. in Essex Institute, says that some foreigners had to be shipped. On the "Margaret" in 1791-2 on the Northwest Coast, all but five of the twenty-four were Americans. Log of "Margaret," 1791-2. MS.

[84] The account of the ship "John Jay" in 1798, MS. in John Carter Brown Library, shows that the wages of a seaman were $15 a month, of the steward and cabin cook $16, of the cook $15, of the boatswain $24, of the cabin boy $6, of the carpenter $23, of the third officer $16, of the second officer $25, of the first officer $30, of the master $16 a month and four tons trading privilege. Forbes, Personal Reminiscences, p. 91, gives one captain's salary as $50 a month.

[85] Parl. Papers, 1821, p. 210, vol. 7, evidence of Drummond. A letter of George Bancroft to C. C. Perkins, Jan. 4, 1879, says, "Young men came from the best families in near and even remote country towns, and entered the service before the mast with a prospect of promotion. The permission given the sailor to take out a little venture of his own was usually rewarded with more lucrative results." C. C. Perkins, Memoir of James Perkins, p. 359.

See also Parl. Papers, 1821, 7:217, evidence of Roberts. Thomas R.

The result of the European wars and the opening of new avenues of trade and an efficient merchant marine, was a phenomenal growth in American commerce with China. In 1789 Shaw mentions four American vessels at Canton[86]; in the season of 1804-5 there were thirty-four, in that of 1805-6 there were forty-two, and in that of 1809-10 there were thirty-seven. The imports to Canton in these last three seasons were $3,555,818, $5,127,000, and $5,715,000 respectively.[87] Although the total commerce of the United States had more than quadrupled in a decade and a half,[88] that with China had nearly kept pace with it, averaging each year four and five per cent of the whole.[89]

This great prosperity, however, was not unmixed with dangers. The China seas were very stormy, and although no cases of actual shipwreck are on record, occasional typhoons wrought havoc, especially as the Americans, unlike the earlier Europeans, persisted in coming at all seasons of the year.[90] Greater were the dangers from men. Since Europeans have known them, the Far Eastern waters have been periodically infested with pirates, and in the decade from 1800 to 1810 an unusually powerful band preyed along the shores of Kwantung Province, and centered around the Bocca Tigris. They were under one head, and in 1810, when finally reduced by the imperial authorities, they were said to have six hundred junks of from eighty to three hundred tons burden each.[91] At first not daring to molest European ships,[92] in the later years of their power they became

---

Trowbridge, Grandfather's Voyage around the World in the Ship Betsey, 1799-1801, New Haven, 1895, tells of a lad eighteen years old having such a venture.

[86] Shaw's Journals, p. 297.

[87] Sen. Docs. No. 31, 19th Cong., 1 Sess.

[88] American State Papers, Commerce and Navigation, Washington, 1832. 1: 927, 928. Exports from the United States, 1791-92, $20,753,098; 1806-7, the banner year, $108,343,150.

[89] This was true at least from 1805 to 1810.

[90] Fanning, Voyages to South Seas, p. 93, tells of such a storm in 1807 or 1808.

[91] John Francis Davis, China. 2 v., London, 1857, 1: 68-71.

[92] Jas. Gilchrist, Journal of a Voyage from Cape Verde Islands to Canton, said, in July, 1808, that the pirates were growing in numbers and would attack a foreign ship if it were in shoal water.

bolder, so much so that vessels found it safe to go from Macao to Whampoa only in fleets of four or five.[93] Several attacks by them are recorded. An entry of a ship's journal, Macao, September 17, 1809,[94] says that an American brig had been captured a short time before and that several others had been attacked. In the same year the "Atahualpa" of Boston was attacked twice, first[95] in Macao Roads and then[96] while going up the river with four other American ships.[97]

More dangerous than the *ladrones,* however, were the French and British privateers and men of war. In 1794, an American ship sailed from Canton under the protection of the returning Macartney embassy from fear of French privateers in the Straits of Sunda.[98] In 1800 Samuel Snow, the consul at Canton, officially warned American ships of danger from them in the same locality.[99] In the same year the ship "Ann and Hope" of Providence was attacked by a Frenchman and drove him off only after a three quarters of an hour's fight.[100]

The French, however, gave less trouble than the English. Here as elsewhere in these years, British claims to the right of search were annoying American commerce. Canton was visited by more American ships than any other port in the Orient, and was hence a convenient place to search them for "deserters." The United States could send no ship of war to interfere,[101] and

---

[93] Journal of the "Hunter" from Salem to Canton and Return, 1808-9, September 17, 1809.

[94] Ibid.

[95] Hunter, Bits of Old China, p. 157.

[96] Charles G. Loring, Memoir of Wm. Sturgis, in Proc. of Mass. Hist. Soc., 1863-1864, Boston, 1864, 7: 420-433.

[97] As late as 1817 there is the record of an attack by pirates on the ship "Wabash" of Baltimore, although the worst nest must have been rooted out some time before. Wilcocks to Secy. of State, Sept. 22, 1817. Consular Letters, Canton, I.

[98] The journal of Mr. Samuel Holmes . . . . during his attendance . . . . on Lord Macartney's Embassy to China and Tartary, 1792-3. London, 1798. p. 198.

[99] Weeden, Early Or. Trade of Prov., p. 253.

[100] George C. Mason, Reminiscences of Newport, Newport, 1884, p. 152, Aug. 17, 1800.

[101] The "Essex" came out in 1800 to ward off French privateers, but got only as far as the Straits of Sunda. Preble, First Cruise of the

Carrington, the consul, could only remonstrate with the British officers and protest to the Chinese authorities. In December, 1804, his demand on the commander of the "Caroline" for the release of some seamen was met with a cool request that it be made through the lords of the admiralty.[102] In October, 1805, he and the other American merchants attempted to petition the provincial governor to stop the impressments, claiming that they were violations of neutrality.[103] Carrington felt sure, however, that the petition would be of no avail,[104] and so it proved, for the hong merchants, knowing that they would be held responsible for the correction of the evils, refused to transmit the complaint.[105] Cut off from any assistance from home and from any hope of interference by the Chinese, Carrington again turned to the British commanders, and attempted to accomplish by correspondence what he had no power to attain by force. In 1806 he carried on an exchange of notes with the commander of the "Phaeton," in the course of which the latter announced his intention of preventing any American ship from sailing without first overhauling it, and finally threatened to prohibit them all from setting to sea.[106] The patience of the Americans became strained to the breaking point by this and similar incidents, and the consul wrote the Secretary of State in April, 1807: "If these outrages are continued, I am extremely apprehensive they will be attended with serious consequences, as it is the determination of the captains of the American vessels to repel by force any attempt in the future to impress their seamen when within this empire."[107] The clash came in August, 1807. On the third the American schooner "Topaz" of Baltimore, William Nicol, master, anchored in Macao Roads after a voyage of contraband trade

---

U. S. Frigate Essex, 1799-1800. Histl. Cols. of Essex Instit., Vol. 10, part 3, pp. 34 et sqq.

[102] Letter of Carrington to Sec. of State, Consular Letters, Canton, I.

[103] Consular Letters, Canton, I.

[104] Ibid., and Carrington to Madison, Nov. 25, 1805. Ex. Doc. 71, 2 Sess., 26 Cong., p. 3.

[105] Ibid., p. 4, and Carrington to Sec. of State, Nov., 1806, Consular Letters, Canton, I.

[106] Consular Letters, Canton, I, and Delano, Voyages, p. 530.

[107] Ex. Doc. 71, 2 Sess., 26 Cong., p. 5.

along the western coast of South America.[108] Captain Kempton of H. M. S. "Diana" examined her papers and searched her for deserters. While he was doing so, some disaffected members of the crew told him that the "Topaz" was a pirate. Captain Nicol feared trouble and obtained permission from the governor of Macao to anchor his vessel under the guns of the Portuguese fort and to put his treasure on land for safe keeping. While the schooner was under way moving to her new position, the English approached again, but were refused permission to come aboard until the vessel should come to anchor. They answered by boarding her by force. In the ensuing fight Captain Nicol was killed, eight of his men were wounded, and the vessel itself was captured and sent to Calcutta. This act aroused the American shipmasters at Canton, and for a time a local war seemed imminent. Commodore Pellew of the English squadron was reported to have threatened to come to Whampoa and capture every American ship there. The American ships, eleven in number, organized themselves into a fleet, appointed a commodore and vice-commodore, and prepared for war. The trouble dragged on into November, when Captain Fanning, if we can believe his story, brought the parties together through his personal acquaintance with the British commodore, and averted further bloodshed.[109] In 1809, however, the "Phaeton" was again impressing American seamen in Canton and was attempting to search American merchantmen.[110]

The War of 1812 was a distinct break in the trade between the United States and China. Here, as in other branches of commerce, fear of capture by the British kept American ships at home. The total commerce of the three seasons from 1812 to 1815 was barely half of that of the year before the war, and

---

[108] Felix Renouard de Sainte Croix, Voyage Commercial et Politique aux Indes Orientales . . . . a la chine . . . . pendant les années 1803-1807, 3 v. Paris, 1810, 3: 130, in a letter written from China, Nov. 17, 1807, tells of this affair, and his story receives corroboration and additions from Fanning, Voyages to S. Seas, 99-113. Both are by men who were either in China at the time or a few months later.

[109] Fanning, Voyages to S. Seas, pp. 99-113.

[110] J. B. Eames, The English in China. London, 1909. p. 136.

less than a third of that for the season of 1809-10.[111] In the Canton factories the merchants of the two nations lived together amicably enough,[112] but at the mouth of the river conflicts frequently took place. In 1814 H. M. S. "Doris" blockaded the American shipping, made several captures, and on one occasion chased a vessel up to Whampoa and captured her in defiance of Chinese neutrality. The Americans at Whampoa armed their boats and captured her, and the Chinese, aroused at last, took measures to punish the aggressors,[113] saying that if the two nations had any "petty qaurrels" they should "go to their own country to settle them."[114]

The struggle was not all one-sided, however. American privateers cruised off the mouth of the river, taking prizes and bringing them in for condemnation,[115] although they did not equal in number those taken by the British.[116] American ships, moreover, occasionally avoided the dangers and brought home cargoes which sold at war prices and netted their owners large profits.[117] From December 20, 1812, to May, 1813, fifteen American ships were brought to Canton and condemned.[118]

---

[111] Sen. Doc. 31, 1 Sess., 19 Cong. Total exports and imports from the United States to Canton, 1812-3, 1813-4, 1814-5 $3,096,500, for 1811-2, $5,903,810, for 1809-10, $11,459,600.

[112] Doolittle, Sketches, p. 41, says, "They lived together as brothers." He himself was there during the war.

[113] Davis, China, 1 : 78-80.

[114] Auber, China, pp. 242 ff., Wheeler, The Foreigner in China, p. 68. It is interesting to note that the differences between the Chinese and the English arising as a result of this incident, led to important concessions by the former, and ultimately to the sending of the Amherst Embassy by the latter. Williams, History of China, pp. 105, 106.

[115] The "Rambler," Captain George Lapham, in 1814, the "Jacob Jones" of Boston in 1815, are two American privateers mentioned by the American consul. Consular Letters, Canton, I.

[116] Ibid.

[117] Niles Register, 7 : 128, Oct. 29, 1814, tells of a New York vessel which had arrived at Newport from Canton with a cargo worth nearly half a million dollars. Parton, Life of Astor, p. 58, says that during the War of 1812 all of John J. Astor's ships from Canton arrived safely when tea had nearly doubled in price. This statement, however, is not strictly reliable.

[118] Consular Letters, Canton, I.

CHAPTER III.

From the Close of the War of 1812 to the Outbreak of the Opium Troubles, 1815-1838.

The effect of the Treaty of Ghent on American commerce with China was quickly felt. The high prices of tea and silk caused by the war stimulated the natural increase due to the resumption of trade, and for the first few years many new firms went into the business, and both the United States and the Continent were flooded with teas, nankeens, and silks. The first season showed a decided increase, the second nearly equaled the largest one before the war, and the three succeeding ones all greatly surpassed it.[1] A new era had dawned on the Canton-American commerce. From about 1790 to the outbreak of the war, the controlling factors had been the European wars and the fur and the South Sea trade. These, as we saw in the last chapter, had been largely responsible for the phenomenal expansion of those years. The beginning of 1815 found the first of these factors a thing of the past, and the others disappearing. The Napoleonic wars had ceased, and the United States was no longer the neutral carrier of the world. The fur trade had nearly reached its end. The sandal wood trade was past its zenith, and only in one minor phase, the *beche de mer* trade, was there any future to those extensive Pacific voyages which had played such an important part before the war. There were new conditions, however, which led to the rapid growth of the Canton trade. In the old-world struggle, trade barriers had been broken down and teas carried in American bottoms still had a market in Europe. The Americans were, too, a more numerous people than in 1790, and wealthier, and there was a growing home market for China goods. They had more commercial capital, and more specie,

[1] Sen. Ex. Doc. 31, 1 Sess., 19 Cong. In 1815-16, imports from Canton were $2,527,500, and exports to Canton were $4,220,000; in 1816-17, they were $5,609,600, and $5,703,000 respectively; in 1817-18, $7,076,828 and $6,777,000 respectively; in 1818-19, $9,867,208 and $9,057,000, respectively; in 1819-20, $8,185,800 and $8,173,107 respectively. The largest year before the war was 1809-10 when the corresponding figures were $5,744,600 and $5,715,000.

and did not stand in such need of furs and sandal wood as a substitute for silver as in 1790. Hence, in spite of the removal of the principal causes of previous prosperity, the years between 1814 and 1834 were, on the whole, successful ones for the Canton trade. For the most part they were quiet and lacked the fever and the romance of the two decades before 1812. Several events are important enough, however, to be chronicled in some detail—the end of the fur and the South Sea trade, the Terranova affair, a change in the American organization of the trade resulting in its concentration in a few large ports and in the hands of a few large firms, changes in the composition of exports and imports, the effect of American trade on the British East India Company, the full development of the community life at Canton, the growing interest of the United States Government in the China commerce, and the beginnings of American Christian missions to the Chinese.

The banner years of the Northwest fur trade had been those immediately before 1808. After this date, in spite of the newer field opened in California, a decline began.[2] The fundamental weakness was not the trouble with England, although the trade did not recover from the blow given it by the War of 1812, but the difficulty of obtaining skins. This was due partly to Russian competition and aggression, partly to the growing difficulty of barter with the Indians, and partly, possibly, to the approaching extinction of the sea otter. In 1816, William Sturgis, a man who had been intimately connected with the trade, said: "The settlements of the Russians and English (particularly the former)

---

[2] The best index of this decline is the importation of sea otter and seal skins, the principal pelts, to Canton. Seal skins came mostly from another branch of the fur trade.

Year	1805	1806	1807	1808	1809	1810
Sea Otter Skins	11,003	17,445	14,251	16,647	7,944	11,003
Seal Skins	183,000	140,297	261,000	100,000	34,000	.....

Year	1811	1812	1813	1814–15	1816	1817
Sea Otter Skins	9,200	11,593	8,222	6,200	4,300	3,650
Seal Skins	45,000	173,000	109,000	59,000	109,000	27,000

Year	1818	1819	1820	1821	1822
Sea Otter Skins	4,177	4,714	2,488	3,575	3,507
Seal Skins	47,290	91,500	24,726	13,887	111,924

have proved highly injurious to the American trade."[3] A little over a year later, Thomas H. Perkins, one of the principal China merchants wrote: . . . . "The Northwest Coast trade . . . . is nearly extinct. . . . As the Russians employed the Kodiack Indians to take the sea otter, the cost of them is very little, as the hunters have very little more than a miserable support for their labor in the chase—we cannot therefore compete with such opponents. . . . The Indians who formerly visited the sea shores to trade with our ships have no longer any inducement to come to the coast, their former occupation being taken away by the enterprise of the Russians and those employed under their direction."[4] Mr. Perkins had made the picture a little too dark, but in the main he was right. Although there were three or four vessels on the coast when he wrote,[5] and although as late as 1826 we find a trading ship starting for the coast,[6] the trade had passed its palmiest days, and had ceased to be an important factor in the commerce with Canton.[7]

Although the Northwest Coast fur trade had practically ceased, its most important diplomatic and political results came after 1820. Negotiations with Russia had, as we have seen, been dropped for a time in 1810. In September, 1821, the emperor astonished the world by issuing a ukase declaring the North Pacific from Behring's Straits to latitude fifty-one degrees north, a *mare clausum* to all whaling, sealing, and fishing. Adams strenuously objected and negotiations followed. The result of

[3] William Sturgis to Charles Morris, Aug. 22, 1816, MS.

[4] T. H. Perkins to Charles Bulfinch, Boston, Dec. 21, 1817, MS. See too on this same subject, Cleveland, Voyages, 1:iv, where much the same view is held.

[5] Perkins to Bulfinch, Dec. 21, 1817. MS.

[6] Journal of the Voyage of the ship "Louisa" from Boston to the Northwest Coast of America, Canton and Boston, William Martin, Master, 1826-9. MS. in Essex Institute.

[7] Furs from inland America continued to be shipped to Canton, however, long after the war. Those of the British Northwest Fur Company were often sent to the Canton market by way of New York and Philadelphia (Reports of Coms., p. 43, 2 Sess., 24 Cong.), and some continued to be taken directly from the United States to China. (Cong. Globe, 1 Sess., 28 Cong., App., p. 226, gives a table showing the fur trade from 1821 to 1840. The direct trade varied from $142,399 in 1821 to $561 in 1840, and $2,368 in 1840, averaging about $60,000 a year.)

these was an agreement signed April 17th, 1824, which fixed the southern boundary of Russian possessions at the parallel 54° 40′ north, and which forbade to Americans the sale of firearms, but allowed them rights of fishing in bays and coasts not occupied by Russian establishments.[8] A futile attempt of the Baron de Tuyl to reopen the question the following summer ended the incident, and American vessels continued to come to Sitka at the rate of from two to four a year.[9]

The Americans had lost for a time all title to the territory north of 54° 40′, but the question of the ownership of the Oregon country was not yet settled, and in its settlement the Northwest Coast fur trade played an important part. It was through this trade that Americans had first come to know the region, and such claims as the discovery of the Columbia River and the settlement at Astoria arose directly through it. Moreover, one of the chief reasons urged for the occupation of Oregon was the acquisition of a Pacific port as a base for the China trade. Floyd, the early champion of the Oregon question, in his report of 1821 to the House, urged that "the Columbia [is] in a commercial point of view, a position of the utmost importance. The fisheries on the coast, its open sea, and its position in regard to China, which offers the best market for the vast quantity of furs taken in these regions, ... seems to demand immediate attention."[10] In the debate of December 17th, 1822, his relative emphasis upon the China trade was still stronger. "The settlement of Oregon . . . . is to open a mine of wealth to the shipping interests . . . . surpassing the hopes even of avarice itself. It consists principally of things which will purchase the manufactures and products of China at a better profit than gold and silver; and if that attention is bestowed upon the country to which its value and position entitle it, it will yield a profit, producing more wealth to the nation than all the ship-

[8] Eugene Schuyler, American Diplomacy and the Furtherance of Commerce, New York, 1886, pp. 292-299.

[9] Frederic Lutke, Voyage autour du Monde, execute par ordre de sa Majeste L'Empereur Nicolas . . . . dans les annees 1826, 1827, 1828, et 1829 par Frederic Lutke, etc., Traduit par F. Boye. 2 v. Paris, 1835. 1 : 131.

[10] Reports of Coms. 45, 2 Sess., 16 Cong.

ments which have ever in any one year been made to Canton from the United States. . . . Were this trade cherished . . . . we could purchase the whole supplies of the United States in the Canton market without carrying one dollar out of the country."[11] He went on to describe the value of the trade, and argued that the grain fields of the Columbia valley could ultimately supply the market of China. The importance of Oregon in the Canton trade was, too, the argument used by the other supporters of Oregon occupation. Baylies and Tucker used it.[12] Colden of New York prophesied that within twenty or fifty years the nearest route to further Asia would be by way of rivers, canals, and portages to Oregon, and thence across the Pacific.[13]

In December, 1824, Floyd was again agitating the question, backing his cause by the same arguments.[14] His bill passed the House, only to be tabled in the Senate, but four years later he renewed the struggle, urging the old reasons.[15] He was defeated and the question was dropped in Congress for ten years. When at last it came up again the advantages of Oregon in the Canton market, although still used incidentally,[16] were no longer the prominent arguments.

It can safely be said, however, that the Oregon Country was preserved to the United States because of the importance it was felt to have in the Canton commerce, and because of the claims to it which the early fur trade had established.

The sandal wood trade did not decline as early as the fur trade or the sealing voyages. In 1817 Kotzebue found it still in full progress on the Hawaiian Islands.[17] The native government

---

[11] Floyd of Va., Speech, Dec. 17, 1822. Annals of Congress, 17 Cong., 2 Sess., p. 398.

[12] Annals of Cong., 17 Cong., 2 Sess., Dec. 18, 1822, pp. 418, 423.

[13] Ibid., pp. 583-586. Jan. 13, 1823.

[14] Register of Debates, 1 : 18-22.

[15] Ibid., 5 : 149.

[16] Woodbury of New Hampshire urged these advantages. Congressional Globe, 3 Sess., 27 Cong., App., p. 93. Hunt foresaw the time when Oregon would command the China trade and a railroad join the Northwest Coast to New York. Hunt's Merc. Mag., 12 : 80.

[17] Otto von Kotzebue, Voyage of Discovery in the South Seas, and to Behring's Straits in Search of a Northwest Passage . . . . in the years 1815, 1816, 1817, 1818, etc., London, 1821, 1 : 189-192.

had obtained control of the sources of the wood and payment was made by the Americans in goods, specie, and in one instance, a ship. In 1825 or 1826, Kotzebue estimated the annual export of sandal wood at $300,000 a year,[18] but this is excessive, as the largest single year's (1822) importation to Canton on American ships was $268,220.[19]

The trade, however, was a wasteful one, and consequently short lived. Sandal wood had disappeared from the Hawaiian Islands by about 1830. On the Fijis it was exhausted by about the same time.[20] Discovered on the Marquesas Group in 1810, it was practically all exported in seven years.[21] The importations to Canton which in 1822 had amounted to 26,822 peculs[22] worth $268,220, had by 1833 declined to the sum of $8,935.

As sandal wood disappeared, a new product, *beche de mer*, was discovered in many of the same localities, and the voyages to the South Seas continued for a number of years longer. They came to be largely in the hands of Salem sea captains[23] and year after year ships went out from the old witch town, hired natives to gather the animal, built huts for cleaning and curing it, sold it at Manila[24] to Chinese epicures at from ten to twenty cents a pound,[25] and brought home cargoes from the Philippines or

---

[18] Otto von Kotzebue, A New Voyage round the World, in the years 1823, 1824, 1825, 1826. 2 v. London. 1830. 2: 191-192.

[19] Pitkin, Stat. View, ed. 1835, p. 304.

[20] Charles Wilkes, in Narrative of the United States Exploring Expedition during the years 1838-1842, 5 v., Philadelphia, 1845, 3: 202, writing of it in 1840 says, "It has for many years past been exhausted." Dix, Wreck of Glide, pp. 30-36, in 1820 said, "Its scarcity hardly repays the labor of searching for it."

[21] M. Camille de Roquefeuil, A Voyage round the World between the years 1816-1819. London, 1823, p. 3. He visited the islands in 1817 and makes this statement.

[22] Parl. Papers, 1830, No. 1, App. 4, pp. 722-723.

[23] Thomas Williams and James Calvert, missionaries to the Fijis, in a work published in London, 1856, said that the traffic on the island in sandal wood, tortoise shell, and *beche de mer* "has been and still is chiefly in the hands of Americans from the port of Salem." Osgood and Batchelder, Salem, p. 170.

[24] This was to avoid the port charges in China. Journal of the Ship "Emerald."

[25] $15 to $25 a pecul (133⅓ lbs.). Wilkes, U. S. Exploring Expedition,

China. In 1837 the "Clay," William Driver, master, made a voyage, selling her cargo in Manila.[26] She was wrecked on her trip back to the Islands.[27] Records of voyages are extant for the "Peru," 1830-1833,[28] for the "Emerald," 1833-1836,[29] for the "Charles Daggett," 1832,[30] for the "Pallas," 1832-1834, for the "Eliza," 1833-1835,[31] and for the "Mermaid," 1836-1839.[32] In 1834 the East India Marine Society of Salem said that fourteen ships from that port had been or were engaged in the trade.[33] Thus for ten years or more (1827 to 1837) there was an extensive South Sea trade from the little New England town.

The South Sea trade was a dangerous one, as the stories of frequent shipwrecks and of troubles with the natives, show. It appealed as a rule to men of adventurous disposition, and not to large firms. Benjamin Morrell of New York, who was typical of his class, made at least four trips to the South Seas, discovering new islands, alternately trading and fighting with the natives, and returning each time to Manila with his cargo of *beche de mer,* tortoise shell, and pearls.[34] Such names on the

---

3: 218-222. This also gives a long description of the way in which it was cured.

[26] Journal of the ship "Clay" in a Voyage from Salem to the Fiji Islands and Manila . . . . 1827-1829. MS. in Essex Institute.

[27] Dix, Wreck of the Glide, also Journal of a Voyage of the ship Glide to the South Pacific Ocean, Henry Archer, Jr., master, 1829-1830. MS. in Essex Institute.

[28] Journal of a Voyage on Board the Barque Peru from Lintin to the Fijis, etc., MS. in Essex Institute.

[29] Voyage of the ship "Emerald" to the Fijis, Tahiti, and Manila, 1833-1836. MS. in Essex Institute.

[30] Felt, Annals of Salem, 2: 559. Charles Erskine, Twenty Years before the Mast, Boston, 1890, p. 153.

[31] MS. Journals of the "Pallas" and the "Eliza" in Essex Institute.

[32] Journal of a Voyage from Salem to New Zealand, the Society, Fegee, Friendly, and other Islands in the Pacific, and home by way of Manila and China, in the Brig "Mermaid," . . . . 1836-1839. MS. in Essex Institute.

[33] Memorial of E. India Marine Society in Reynolds, Address, pp. 167-170.

[34] The accounts of these voyages are by participants. Morrell, Voyages. Abby Jane Morrell, Narrative of a Voyage to the Ethiopic and South Atlantic Ocean, Chinese Sea, North and South Pacific Ocean, in the years

map as Fanning's Island and Sandal Wood Bay bear witness to the existence and pioneer nature of the early American trade in those far away regions.

After the second war with Great Britain the life of the Americans at Canton was without unusual excitement until the Terranova affair, in September and October, 1821. This gave rise to the only cessation of American trade previous to the opium troubles, and illustrates well the position of the foreigner in China prior to the treaties of 1842-4. Three fundamental facts explain it: the complete lack of diplomatic intercourse and treaties between foreign nations and China, and hence of a mutually recognized means of adjusting international difficulties; the firm conviction of the natives that foreigners were of an inferior barbarous race which must be governed with a firm hand; and the policy of western governments, especially of the United States, of keeping entirely aloof from the Chinese government and of granting no powers other than commercial to the consul. These three conditions made all intercourse uncertain. The system was admirable as long as all was harmonious, but the moment that difficulties arose it broke down. The Terranova trouble began in the latter part of September, 1821. While near the "Emily," Captain Cowpland, of Baltimore, a woman fell from a boat and was drowned. It is probable that her death was accidental, but the Chinese authorities at once accused Terranova, an Italian sailor on the ship, of having killed her by dropping a fruit jar on her head,[35] and demanded his surrender. Cowpland, although putting Terranova in irons, refused to surrender him. The Americans organized a committee of five resi-

---

1829, 1830, 1831, etc., New York, 1833, and Thomas Jefferson Jacobs, Scenes, Incidents, and Adventures in the Pacific Ocean . . . . during the Cruise of the clipper "Margaret Oakley" under Captain Benjamin Morrell, New York, 1844. The first voyage was in 1828, the second in 1829, the third in 1830, and the fourth in 1834. The records of the last are given by Jacobs.

[35] George Thomas Staunton, in Miscellaneous Notices Relating to China, etc., London, 1822-1850, pp. 409-432, denies that there was a Chinese law requiring a life for a life in case of accident, and says that even in case of punishment, a death penalty was not necessarily inflicted. He assigns the Chinese severity in the Terranova affair to the desire to "inspire foreigners with awe."

dent merchants, five supercargoes, and five masters of ships to conduct the case, and Cowpland placed himself under their direction.[36] Wilcocks, the American consul, felt that his authority did not permit him either to try the case himself, or to deliver the prisoner to the native authorities, and so confined himself to coöperation with the committee. The latter met the hong merchants and after some discussion it was agreed to hold the trial in the American factory with Morrison, the English missionary, as interpreter, and Wilcocks present to take notes. The viceroy, however, wished the place changed to the "Emily," and this was done. There next broke out a sharp discussion over the form of the trial. The officials objected to Morrison being present[37] and refused to give Wilcocks a seat. Both finally were absent. On October 6th, the trial took place on board the "Emily" in the presence of a Chinese magistrate and the hong merchants. From the American standpoint it was mere mockery. The magistrate came convinced of the Italian's guilt; he cut off the latter's attempt at explanation, refused to consider any evidence but that which was against the prisoner, and finally demanded that the prisoner be given up. This the Americans refused to do, although they said that they would offer no resistance if the authorities were to take him off by force. Resistance, indeed, was useless, as all firearms had been taken away and the ship surrounded by a throng of Chinese. The magistrate, however, was unwilling to take the prisoner in this way, and after some discussion withdrew.

The day following the trial every pressure was brought to bear to obtain Terranova's surrender. An embargo was laid on all American trade. The "Emily's" *linguist* and *fiador* were imprisoned, and threatened with death in case of armed resistance by the Americans. The committee, however, refused to give up the prisoner, although still promising to make no

[36] The facts of the Terranova case here given, unless otherwise stated, are procured from the lengthy reports of the proceedings sent to the Secretary of State by the Consul, Wilcocks, contained in Consular Letters, Canton, I.

[37] Execution of an American at Canton; North American Review, 40:58:68. It says that the objection to Morrison was on the ground that he was British, and the officials did not wish to get into trouble with more than one nation.

resistance should the Chinese come and take him by force, "placing a firm reliance in the Government of the United States for a redress of our grievances upon proper presentation of the facts." After repeated conferences between the committee and the cohong, and after repeated assurances that the Americans would offer no resistance,[38] on October 23d,[39] the hong merchants went to the "Emily" in force and took off Terranova as a prisoner of state. The Italian once in their hands, the Chinese acted promptly. October 26th he was tried before local magistrates behind closed doors, all foreigners being carefully excluded. He was quickly condemned and strangled, and his body was returned to the "Emily." American trade was at once reopened, since, said the viceroy in his edict, "the said chief [Wilcocks] has on the whole behaved respectfully and submissively." The edict closed in a grandiloquent way which illustrates the Chinese attitude throughout the entire proceedings: "The Celestial Empire's kindness and favor and tenderness to the weak are rich in an infinite degree. But the nation's aspect sternly commands respect, and cannot because people are foreign sailors, extend clemency to them. Let the Hong merchants explain luminously this official mandate, and persuade and induce the said foreigners, all of them, to know it, and to be thereby filled with reverence, and awe; that each may insure the safety of his own person and family, and not bring himself into sorrow."[40]

The Americans have been criticised for making no further resistance, and the United States Government for taking no action to obtain satisfaction. The merchants and sea captains at Canton could not have assumed a firmer attitude, however, without grave danger to themselves, the certainty of bloodshed, and the possibility of war, and the consul could not have done more without exceeding his authority. It may be said further, both

[38] The cohong knew that further bloodshed would mean more trouble for them.

[39] The account in the North American Review says Oct. 25th, but Wilcocks' date is to be preferred.

[40] Consular Letters, Canton, I. Other accounts of the affair may be found in Staunton, Notices Relating to China, pp. 409-432, Davis, China, 1: 90, 91, and in Foster, Am. Dipl. in the Orient, pp. 40, 41.

for the United States Government and for the American merchants, that until a treaty should specify otherwise, those who traded in China were under obligation to hold themselves amenable to its laws. It is to be regretted, however, that the inevitable issue between the Middle Kingdom and the Occident, free intercourse between the two on a basis of mutual equality, could not have been forced by the United States at this time, and over a test case of this nature, rather than by England nineteen years later over the opium traffic.

The years following the War of 1812, were, as we have seen, marked by the rapid recovery and growth of the Canton-American commerce. A reaction, however, was inevitable. Over-optimistic merchants imported too largely on credit, too many inexperienced men were drawn into the trade,[41] the market became overstocked, and commercial failures followed.[42] There was a slight increase in trade immediately after 1819,[43] perhaps because of the general depression, but the real crisis came in 1826. After that year, in sharp contrast to the previous prosperity, there was a sudden cessation in the importations of Chinese goods to Providence, apparently attended with serious losses.[44] Thomas H. Smith, one of the most prominent tea merchants of New York, became insolvent, carrying many smaller firms with him,[45] and Thompson, a prominent merchant of Philadelphia, who was associated with Smith, went into a disgraceful bankruptcy, owing the government a large sum for duties.[46] Imports and exports to and from China fell off a third, and did not recover until 1833.

---

[41] Testimony of Joshua Bates of Baring Bros., before the Select Com. on the E. India Co., Parl. Papers 1630, 5:218. He had been connected with the American trade with China for twenty years.

[42] Ibid., 6:365-380.

[43] The figures are in Pitkin Stat. View (ed. 1835), p. 303, and in first report of the Com. on E. India Co. Affairs, Parl. Papers, 1830, 5:20.

[44] The losses fell especially on Edward Carrington and Co., and the smaller dealers associated with them. None entered again as extensively into the trade. May 18, 1827, is the last entry of a China ship until July 5, 1831. Providence Custom House, Impost Book, 1827, and Ibid., "D," p. 16. Mss. in Rhode Island Historical Society.

[45] Barrett, Old Merchants of N. Y. City, p. 87.

[46] Ibid.

The most marked permanent effect of this crisis was to hasten the change which was taking place in the United States in the commercial machinery of the Canton commerce. Up to the War of 1812 the commerce had been in the hands of a comparatively large number of firms and individual investors, small for the most part, and scattered among nearly all the seaports of the North Atlantic states. Beginning about the time of the war, trade began to decline in the smaller ports, New Haven, Stonington and Norwich, and later Providence and Salem, and to be confined to the larger cities, New York, Boston, and Philadelphia, where it was concentrated in the hands of large firms. The change can be best seen by sketching the history of the participation of each of these ports in the China trade, taking them in their geographical order.

Salem, the northernmost port of importance, began its connection with China in January, 1786, when the "Grand Turk," belonging to Elias Hasket Derby, sailed for Canton.[47] In 1790 four ships were entered from Canton.[48] The trade then seems to have been abandoned for several years, and we do not find that another China ship arrived until 1798.[49] For several years after this the trade was on the increase. It suffered somewhat in the troublous times preceding and during the War of 1812, and shared the rapid growth after the war. After 1820, however, it fell off permanently and was thereafter continued only intermittently. In all, from 1790 on, thirty-five cargoes are entered in the Salem custom house as being from Canton, and five more which are entered from other ports on the Canton trade route contained tea.[50] After all that has been popularly reported about the importance of Salem in the China trade these figures

[47] Rantoul, The Port of Salem, Histl. Cols. of the Essex Instit., 10: 55.

[48] Digest of Duties of the Salem Custom House, 1789-1852. MS. in Salem Custom House.

[49] Ibid.

[50] By years the figures are as follows from the opening of the United States Custom House in Salem: 1790, 4; 1798, 1; 1800, 1; 1802, 2; 1803, 1; 1804, 1; 1807, 1; 1808, 1; 1810, 2; 1812, 1; 1817, 1; 1818, 3; 1819, 3; 1820, 2; 1825, 2; 1826, 1; 1829, 2; 1830, 1; 1831, 1; 1832, 1; 1834, 1; 1836, 1; 1841, 1. Total, 35. All but two of the voyages from 1829 on were made by one ship, the "Sumatra." Digest of Duties, Salem Custom House.

are surprisingly small, especially when we remember that there were often entered in one year at Canton more than forty American ships.[51]

The first great Salem merchant in the China trade was Elias Hasket Derby. He made a fortune in privateering during the Revolution[52] and entered the Far Eastern trade soon after the treaty of peace. Most of the Salem ships at Canton before 1800 were his.[53] The most prominent merchant of Salem after the second war with Great Britain was Joseph Peabody. He began his career in one of Derby's privateers during the Revolution,[54] and retired from the sea in 1791 to become a merchant trader. His vessels made seventeen voyages to Canton.[54] With possibly one exception all the Salem-China voyages after 1826 were under him.[55]

The origin of the Boston-China commerce was closely connected with that of Salem. Thomas Handasyd Perkins went out as a supercargo in the "Astrea," one of Derby's ships, in 1789 and 1790.[56] While at Canton he met the "Columbia," just

---

[51] Sen. Docs., No. 31, 1 Sess., 19th Cong.

[52] George Atkinson Ward, Joseph Peabody, in Freeman Hunt's Lives of American Merchants, New York, 1856, p. 372.

[53] Trow, Old Shipmasters of Salem, p. 45. Trow says that at the time of his death Derby was the richest man in the United States. See also on Derby, Cleveland, Voyages, 1:1, Weeden, Ec. and Soc. Hist. of N. Eng., p. 822.

[54] Ward, Joseph Peabody, in Hunt's Lives of Am. Merchants, p. 380.

[55] Digest of Duties, Salem Custom House, 1789-1851. Impost. Book No. 8, Salem Custom House. The first gives the list of voyages, the second shows that in the "Leander" in 1826, and the "Sumatra," 1830, the principal part of the duties was paid by Peabody, and as all voyages but one, that made by the "Eclipse" in 1832, were made by these two ships, the inference that Joseph Peabody was the principal investor seems a fair one. On Peabody see also Osgood and Batchelder, Salem, p. 134, and Trow, Old Shipmasters of Salem, p. 45. William Gray, later of Boston, was in the Salem-China trade for a time. Edward Gray, William Gray of Salem, Merchant, Boston and New York, 1914.

[56] Abbreviations of a Journal of the ship "Astrea," MS. in Essex Institute, and Thomas G. Cary, Memoir of Thos. H. Perkins, in Hunt's Lives of Am. Merchants, pp. 33-101. See also N. Eng. Hist'l and Genl. Register, 10:201-211, for a review of it. Cary was a son-in-law of Perkins, and this memoir should be authoritative.

arrived from its first voyage to the Northwest Coast, and learned of the great possibilities of the fur trade. On his return he sent out the "Hope," Ingraham, master, and later, the "Margaret" under James Magee, a former captain of the "Astrea." In 1792 he formed with his brother the partnership of James and Thomas H. Perkins, which in 1838, when dissolved, was the most prominent of the American-Chinese firms. At first they were engaged only in the Northwest Coast fur trade, but in 1798 they began sending ships directly to Canton, and finally entirely confined themselves to this.[57] A branch house was established at Canton and another at Manila.[58] More or less closely allied with James and Thomas Perkins by blood or business relations were Samuel Cabot, the Lambs, John P. Cushing, Thomas T., John M., and Robert B. Forbes, James P. Sturgis,[59] and the firm of Bryant and Sturgis,[60] part of whom were in China and part in the United States. Into the hands of these houses went most of Boston's share in the China trade, and they furnish the best example of the semi-monopoly which characterized the China trade during this period. The nephews and cousins of the members of the firm were trained in counting houses or on the ships to take up the business as the older men laid it down. Other Boston firms there were, such as the Lymans—great rivals of the Perkins[61]—Dorr and Sons, J. Coolidge, Bass, J. Gray, Thomas Parish, and Hoy and Thorn,[62] but unfortunately there exist no easily accessible materials for their history. The destruction of the early papers of the Boston Custom House, too, prevents a sketch of the port's trade as a whole. From what little survives of the original records, it can be safely asserted that with the years, the relative importance of Boston in the China trade increased, and that the Perkins family and its allied

[57] Letter of Perkins to Bulfinch, Dec. 21, 1817. Ms.

[58] Robert B. Forbes, Personal Reminiscences, Boston, 1878, p. 88. See also on the history of Perkins and Co., in addition to the authorities mentioned thus far, C. C. Perkins, Memoir of James Perkins, and Letters and Recollections of J. M. Forbes.

[59] Forbes, Personal Reminiscences, pp. 39-64, and passim.

[60] Ibid., p. 131.

[61] T. L. V. Wilson, Aristocracy of Boston, Boston, 1848, p. 26.

[62] Tufts' Acct. of Vessels in Sea Otter and N. W. Trade.

firms became more and more prominent. The troublous times of 1826, while wrecking other houses, seem to have affected them but little.

Of the Rhode Island cities only one can boast of a large trade. At least two voyages seem to have been made from Newport to China,[63] and a few were fitted out by the D'Wolfs of Bristol for the Northwest Coast trade,[64] but Providence had the lion's share. Beginning with the "General Washington" in 1789,[65] sixty-eight voyages from Canton terminated there, nearly twice as many as at Salem.[66] The number increased to 1803, and then with the exception of 1810 gradually decreased to 1812. After the war there was a sudden increase again, with a decline in 1820, a second rise in 1822, and an entire break from 1827 to 1831 caused by the failures of 1826. From this break the trade never fully recovered. A few more voyages were undertaken by a single firm, but even these came to an end in 1841, and as in the case of Salem the China trade passed into the hands of larger ports and larger firms.[67]

---

[63] By the "Semiramis," Mason, Reminiscences of Newport, pp. 149, 153.

[64] Tufts' Acct. of Vessels in the Sea Otter and N. W. Trade.

[65] Log book of the "General Washington." 1787-1790. MS. in John Carter Brown Library. She went out in 1787.

[66] They are as follows by years: 1789, 1; 1791, 1; 1793, 3; 1795, 2; 1796, 1; 1797, 1; 1798, 2; 1799, 1; 1800, 3; 1801, 1; 1802, 2; 1803, 6; 1804, 2; 1805, 3; 1806, 2; 1808, 1; 1809, 1; 1810, 4; 1811, 1; 1812, 1; 1816, 2; 1817, 2; 1818, 2; 1819, 5; 1820, 1; 1822, 3; 1823, 3; 1824, 1; 1825, 1; 1826, 2; 1827, 1; 1831, 1; 1832, 1; 1833, 1; 1835, 1; 1838, 1; 1841, 1; Total, 68. The years not mentioned had no voyages. Providence Custom House Impost Books.

[67] The main Providence firms were Brown and Ives, organized in 1795 (Weeden, Early Oriental Trade of Providence, p. 240), and its predecessors, Brown, Benson, and Ives, and Brown and Francis. It was Brown and Francis who sent out the "General Washington" on its first voyage; Brown and Ives sent ships intermittently through the years, imported the largest single cargoes which came to the port from Canton; appeared among the consignees in nearly half of the voyages, and had a part in the ship "Hanover," in 1838, the next to the last of the Providence-Canton voyages. (Providence Custom House Impost Books, passim.) The other firms in the trade, mostly dating from before 1800, were John Corlis, Clark and Nightingale, John I. Clark, Edward K. Thompson, Benjamin Hoppin and Son (or T. C. Hoppin), and Edward Carrington and Company. Of these, Edward Carrington and Company was the most impor-

In the little ports along the Connecticut coast there were no large firms, but only a short-lived activity in sealing. Stonington, Hartford, New London, and New Haven, each had their small share. The activity was large for a time, but it was only in sealing, an adventurous, self-destructive trade, and was necessarily of relatively short duration. It had practically ceased before the War of 1812.

It was from New York that the American trade with China was first begun, and that city continued to be one of the three chief ports interested. To a certain point the course of trade seems to have been much the same as in Salem and Providence—an increase to about 1805 and 1806, a decrease to the war, and an increase immediately after it. Unlike Salem and Providence, however, an increase rather than a decrease followed the depression of 1826.[68] As in Boston, we find a few prominent firms, but unlike Boston, no single one predominated through the entire period. John Jacob Astor was early in the trade, and kept it up after the war.[69] A story which unfortunately is not well authenticated ascribes the foundation of his great fortune to his early success in the trade.[70] Oliver Wolcott and Company and

---

tant. It almost monopolized the trade for a few years after the war, but suffered heavily from the depression in 1826, and only entered again after some years, and then as a minor investor. (For further information on the part of Providence in the China trade, see Weeden, Early Oriental Trade of Providence, Kimball, East India Trade of Providence, and the files of the Providence newspapers, especially the Providence Gazette. The Brown and Ives papers are in the custody of the John Carter Brown Library in Providence, and contain a great mass of manuscript material, of which the log books are the most easily accessible.)

[68] See Letters and Clearance Books of the New York Custom House, Mss. in New York Custom House, passim. These are incomplete, but for the years they cover, they show the following numbers of vessels clearing: 1799, 4; 1800, 7; 1801, 2; 1802, 7; 1805, 8; 1806, 9; 1807, 2; 1809, 7; 1818, 3; 1819, 3; 1829, 5; 1830, 5; 1831, 4; 1832, none; 1836, 5; 1844, 11; Total for sixteen years, 82.

[69] Ibid.

[70] Barrett, Old Mercs. of N. Y. City, 1: 417-421. Astor is there said to have told the story as that of the beginning of his fortune, but I find no corroborative evidence. James Parton, Life of John Jacob Astor, New York, 1865, p. 49, says that he sent out his first ship about 1800, and that he continued the commerce for twenty-seven years, "generally with profit and occasionally with splendid and bewildering success."

H. Fanning also engaged in it in these early years.[71] But it was not until after the war that great firms began to dominate the trade. Of these Thomas H. Smith had the most meteoric course. Entering in the period of expansion which followed the treaty of peace, he was soon exporting on a large scale.[72] He went into the business too extensively, however, and failed in 1827, owing the custom house three million dollars.[73] Another firm, more stable, noted for its non-importation of opium and its friendliness to missionaries, was Olyphant and Company. D. W. C. Olyphant, its head, had gone out to Canton in 1820[74] and again in 1826 as the agent of Thomas H. Smith, and when in 1827 the latter failed, he returned to New York and organized the firm which bore his name.[75]

Turning to Philadelphia, we come to the southernmost of the three ports which controlled the China trade in these later years. Robert Morris had had a share in the "Empress of China" and had later sent out several vessels of his own, including the famous "Alliance." In 1806 thirteen ships arrived from Canton,[76] and in 1839 and 1840, seven different vessels were employed in the trade.[77] Some of the principal firms were Eyre and Massey (1803-1845), one of whose ships made eight round trips to China,[78] Charles Wharton,[79] Jones and Clark,[80] John Clement

---

The first manuscript mention I find is of the ship "Severn" which he sent out in Jan., 1802, joining some other merchants in the investment. See Letter Books, N. Y. Custom House.

[71] See Letter Books of N. Y. Custom House, and Store Book of Oliver Wolcott and Co., Ms. in New York Historical Society's Library, pp. 162, 167, 83, 84, 24, 59, 32.

[72] $1,311,057.22 in 1824 and nearly $1,740,000 in 1825. Sen. Doc. 31, 1 Sess., 19 Cong. He had seven ships regularly employed. Hunter, Fan Kwae at Canton, p. 1. He went out on one of these ships in the employ of Smith.

[73] Barrett, Old Mercs. of N. Y. City, p. 33.

[74] Mrs. Robert Morrison, Memoirs of the Life and Labors of Robert Morrison, 2 v., London, 1839, 2:86.

[75] Hunter, Fan Kwae at Canton, p. 15.

[76] Adam Seybert, Statistical Annals, Philadelphia, 1818, p. 55, from the Custom House Records.

[77] Consular Letters, Canton, III. The figures for other cities were, Providence, 1, New York, 10, Boston, 12, Salem, 4, Baltimore, 2.

[78] Abraham Ritter, Philadelphia and Her Merchants, as Constituted

Stacker,[81] Archer, Jones, Oakford and Company,[82] and John McCrea, who was even more of a speculator than Thomas H. Smith,[83] and Stephen Girard who in 1791 built several ships for the China trade.[84] The China trade of the city successfully survived the depression of 1826.

Baltimore was never as actively engaged in the trade as were the more northern ports, and although she began early, the first ship from Canton arriving August 9, 1785, her commerce with China did not flourish as did that of her more advantageously situated rivals.[85] No other southern port seems to have entered the trade with any earnestness.[86]

From this brief and necessarily incomplete review of the participation of each of these ports in the commerce with China, the general tendency to centralization is apparent and a more minute study would show it more clearly. The crisis of 1826 only hastened a process which had begun several years before and which continued until about 1840.

The years between 1815 and 1839 saw a development in the art of ship-building. The famous "clippers" were born in the trade with China. The "Ann McKinn" of Baltimore was built in 1832 for the China trade. The "Akbar" was built in 1839 for John M. Forbes and made the trip from New York to Canton in the record time of one hundred and nine days. After 1839,

---

Fifty to Seventy Years Ago. Philadelphia, 1860, p. 60. This statement is made on the authority of Charles Massey of that firm.

[79] Ibid., p. 181.

[80] Ibid., p. 195.

[81] Ibid., p. 199.

[82] Sen. Doc. 31, 1 Sess., 19 Cong.

[83] Barrett, Old Mercs. of N. Y. City, pp. 45 and 97. Unfortunately there is not enough information to give a more connected sketch of Philadelphia's trade with China.

[84] Paullin, Diplom. Neg. of Am. Nav. Officers, p. 165.

[85] B. Mayer, Histl. Sketch of Baltimore in F. A. Richardson and W. A. Bennett, Baltimore Past and Present, with Biographical Sketches of its Representative Men. Baltimore, 1871, pp. 53, 63.

[86] One ship seems to have been sent from Charleston to the East Indies, but it is not certain that it touched at Canton. David Ramsay, The history of South Carolina from its first settlement in 1670 to the year 1808. 2 v. Charleston, 1809, 2:239. One ship went from Norfolk, Va., in 1786. Paullin, Diplom. Neg. of Am. Nav. Officers, p. 162.

but before 1844, a number of swift boats of comparatively light tonnage were built for carrying opium. They were owned by J. M. Forbes and Russell and Company and soon controlled the opium trade. So, although clipper ships did not attain their supremacy until after 1844, their lines first began to be worked out in the thirties.[87]

The period between 1815 and 1839 was marked by changes in imports and exports to and from China no less noticeable than those in the commercial organization. No generalization can safely be made: one must rather take up the principal articles individually.

Of the American imports to China the most important was specie.[88] Until bills of exchange began to take its place, it formed half and even three-fourths of the total, amounting in one instance to nearly seven and one-half millions of dollars.[89] The drain was heavy but necessary. American merchants found it profitable to import teas, even when paying for them with so expensive a commodity. In some years it was in such demand that a premium had to be offered in the United States to obtain enough for a cargo.[90] Most of it was in the form of Spanish milled dollars obtained from the Spanish West Indies, South America, Portugal,[91] and Gibraltar.[92] So accustomed to these dollars did the Chinese merchants become that when those of the new South American states began to come in, they were received only at an excessive discount.[93] About 1827 bills of exchange on England began to take the place of specie.[94] The large

---

[87] A. H. Clark. The Clipper Ship Era, New York and London. 1911. pp. 58-60.

[88] For tables see footnote 3 on page 469.

[89] In 1819 the imports of specie to Canton amounted to $7,414,000. Pitkin, Stat. View, ed. 1835, p. 303.

[90] The Columbian Centinel, Boston, on Feb. 13, 1802, and Oct. 20, 1802, contained advertisements offering a premium on Spanish dollars for ships about to sail to Canton.

[91] Weeden, Early Oriental Commerce of Providence, pp. 274-276.

[92] Letters and Recollections of J. M. Forbes, 1:70.

[93] It required a special edict of the Hoppo to reduce this discount to a just one. The Canton Register, Canton, 1827 et sqq. Vol. 8:91835. No. 10.

[94] See tables footnote 3, page 469.

importation of opium by the British turned the balance of trade against China and made it cheaper to buy exchange than to ship silver, and the days of the latter's prominence as an export were at an end.[95] In 1833 specie amounted to only one-seventh of the sum of the bills on England, and merchandise to less than two-thirds.

Another article of importation to China, new in this period, was cotton. It is true that America purchased nankeens at Canton, but later the increased quality and cheapness of the coarser cottons of the Occident won for them a market in the East. About half of that imported in American ships was from the United States, the rest being from England.[96] For American raw cotton there was little demand, since the Indian product was cheaper.[97]

Some imports to China need only the briefest mention. Quicksilver began to be brought in about 1816. It varied greatly in amount, running in value all the way from $747,600 in 1819 to $17,971 in 1833.[98] Rice was imported from Batavia and Manila during these years in increasing quantities[99] because the cumshaw tax was not charged by the Chinese on vessels which brought it.[100] Copper was brought from South America, some years to

---

[95] This is the reason given by Mr. Sturgis, a famous China merchant, in a lecture reported in Niles Register, 68: 343. Aug. 2, 1845. See also A. J. Sargent, Anglo-Chinese Commerce and Diplomacy (Mainly in the Nineteenth Century). Oxford, 1907, p. 56. Hosea Ballou Morse, The Trade and Administration of the Chinese Empire, New York, etc., 1908, p. 330, takes a somewhat different view.

[96] Ex. Doc. 35, 3 Sess., 27 Cong.

[97] Niles Register, Jan. 20, 1844, 65: 332-333, quotes from the New Orleans Bee to that effect. Tables in Chinese Rep. 16:47, show no imports of raw cotton before 1843. The first cargo seems to have been brought from New Orleans in the "Delhi" in 1843. Journal of a Voyage in the ship Delhi from New York to New Orleans, New Orleans to Canton, etc., in 1843-4. MS. in Essex Institute.

[98] Pitkin, Stat. View, ed. 1835, pp. 300, 304. See, too, Phipps, China and European Trade, p. 313, and Sen. Doc. 31, 1 Sess., 19 Cong., "G."

[99] The value was $866,367 in 1836-7. Ch. Rep., 6: 284-286.

[100] Reports of Select. Com. on E. India Co., Parl. Papers, 1830, 5: 122, Evidence of Abel Coffin. In 1833-4 this was $311,315 (Murray, Hist. and Desc. Acct. of China 3:74), but two years before it was only $21,342. Phipps, China and Eastern Trade, p. 313.

the value of more than $300,000. Lead was brought in ingots from Gibraltar and elsewhere to the value of about half that of copper.[101] A very little steel was brought in from England and Sweden.[102] The importation of opium by Americans was always much less than that by the English, and most of it was the inferior kind obtained in Turkey. Figures are difficult to obtain for it, since it was a contraband article, but it seems to have been first regularly imported about 1816. One year, 1831-2, it was brought in to the value of more than two million dollars[103] but this seems to have been its high-water mark. In few years did it approach that amount. Ginseng still continued to be shipped from America, but rarely to the value of $200,000.[104] Rattans, pepper, nutmegs, tin—from the Straits Settlements—cochineal, cloves, and coral, are all articles which appear with more or less regularity in the list of minor imports,[105] but none of them were of great importance. It is hard to tell just when their importation began.

One last group of American imports to China, British manufactures, needs more than passing mention, partly because of its value,[106] partly because it illustrates American enterprise, but

---

[101] Ch. Rep., 2: 463. Letters and Recollections of J. M. Forbes, 1: 70.

[102] Chinese Repos., 2: 471.

[103] Phipps, China and Eastern Trade, p. 313.

[104] Pitkin, Stat. View., ed. 1835, p. 49.

[105] Phipps, China and Eastern Trade, p. 313, and Chinese Rep. 6: 284-286.

[106] Parl. Papers, 1820, 5: 183. Testimony of Charles Everett, an American Commission Merchant. He gave as the amounts shipped in this way through him, for 1818, 1,809 lbs. sterling, for 1819, 26,448 lbs. sterling, for 1820, 139,639 lbs. sterling, 1821, 190,190 lbs. sterling, 1822, 28,468 lbs. sterling, 1823, 67,048 lbs. sterling, 1824, 125,681 lbs. sterling, 1825, 7,408 lbs. sterling, 1826, 168,354 lbs. sterling, 1827, 45,696 lbs. sterling, 1828, 51,481 lbs. sterling. Joshua Bates, Ibid., 6: 365, testified that one firm (probably Perkins and Company) had exported in 1826, 120,000 lbs. sterling, in 1827, 82,000 lbs. sterling, in 1828, 98,000 lbs. sterling, in 1829, 147,000 lbs. sterling. The East India Company estimated the amount for 1823 as 107,531 lbs. sterling, of which 32,614 lbs. sterling were in cottons, and 73,083 lbs. sterling were woolens. Ibid., pp. 724-727. Parl. Papers, 1833, E. India Co. Papers relating to trade with India and China, from S. Cabell, Accountant General of E. India Co., give the figure for 1829-30 as $11,122,066, for 1830-1 as $781,429, for 1831-2 as $637,822, and of the E. India Co. for these years, as $2,675,371, $2,818,766, and $2,956,209 respectively.

chiefly because of its effect upon the East India Company. The importation of these goods began shortly after the War of 1812, possibly in 1818.[107] An absence of discriminating port charges and duties, except a small one of two per cent in London,[108] the fact that the American merchant while charging the same price in China bought in England a quality of goods slightly inferior to those of the East India Company, and the exclusion of all English free traders from the market gave a rapid growth to the trade. This was very disquieting for the English. They had long watched American trade with China with growing uneasiness and at its very beginning Phineas Bond and the other British agents in the United States had kept the ministry informed of its progress. At first the attitude of English observers was one of security or indifference. Lord Sheffield, in his "Observations on the Commerce of the American States," published first in 1783, entirely ignored the possibility of a direct trade with China, and a London paper of March 16, 1785, said that the Americans had "given up all thought of China trade."[109] By 1813, however, English opponents of the East India Company were beginning to point to the rapid growth of the American-Canton commerce, to contrast it with the slow increase of the British trade under the monopoly, and to use it as an argument for making the English commerce with Canton free.[110] In 1819, Assey pointed out in a pamphlet "the insecurity of the present trade from Great Britain and British India to China if timely measures of precaution be not taken to meet the progress of the Americans in China."[111] So strong was the outcry on this score by the opponents of the monopoly[112] that a

---

[107] Charles Everett says that he was the first to ship English manufactures in this way, and that he began in 1818. Ibid., Papers, 1830, 6: 361.

[108] Testimony of Joshua Bates, Ibid., 6: 365-380. Lindsey, History of Merchant Shipping and Ancient Commerce. London, 1876, pp. 105, 106.

[109] Hill, Trade and Commerce of Boston, p. 81.

[110] "Additional Considerations upon the China Trade," written in 1813, in defense of the East India Company, tries to answer this argument. Staunton, Notices Relating to China, p. 178.

[111] Charles Assey, on the Trade to China and the Indian Archipelago, etc., in the Pamphleteer, Vol. 4, London, 1819, p. 516.

[112] Staunton, Notices Relating to China, p. 299, publishing part of a letter

large proportion of the time of the House of Lords' Committee on the Foreign Trade which in 1820 and 1821 investigated the East India Company was spent in gathering information on American commerce with China. The evidence showed the Americans to be so successful with unrestricted trade that the committee reported favorably on a similar plan for Great Britain.[113] In 1829 and 1830 the discussion again came up in Parliament, and again the American trade was the chief argument. By this time the growth of American shipments of British woolens had long been noticeable. It galled British pride to see the Yankees come to England and carry British manufactures to Canton. The East India Company tried in vain to prevent it,[114] and the independent merchant raged at being compelled to see Americans accumulate fortunes from profits which he felt belonged to him. In public meetings,[115] in the press,[116] and on the floor of Parliament,[117] American trade was

---

answering a memorial of British ship-owners which had instanced the American commerce with China in favor of free trade.

[113] Parl. Papers, 1821, 7: 5.

[114] Wood, Sketches of China, p. 64, says (in 1827-8), "The extensive importation of British goods in American vessels had been materially detrimental to the Company's trade in China, and as they found it impracticable to prevent the exportation from England by Americans, they resolved to thwart them by using their influence to affect their sales in Canton."

[115] Proceedings of a Public Meeting of the India and China Trade, Liverpool, 1829. The meeting was a protest against the East India Company's monopoly of the China trade, and frequent mention was made of the American trade.

[116] An article in the Edinburgh Review, Jan., 1831, 52: 281-322, against the East India Company's monopoly attracted much attention. It cited the success of the American trade as an argument; an argument which John Slade, Notices on the British Trade to the Port of Canton, etc., London, 1830, p. 32, and British Relations with the Chinese Empire, ca. 1832, both attempt to refute.

[117] Huskisson, in speeches May 12 and 14, 1829 (Hansard's Debates, 2 Series, Vol. 21, pp. 1296 and 1365), and Whitmore, May 14, 1829 (Ibid., p. 1349). The latter said, "The Americans find no difficulty in carrying on their free trade with China, supplying not only the United States, but all the world except Great Britain with Chinese produce, and importing even British manufactures into Canton."

cited as a reason for ending the monopoly. The result was the defeat of the company.[118] Contrary to English expectations, however, this shipment in American vessels did not cease with the end of the monopoly, but continued to 1837 at least[119] and possibly longer.

From a consideration of the imports to China in American ships we naturally turn to the exports. Of these tea was pre-eminent. Choosing representative years, in 1822, 6,639,434 lbs. were imported into the United States, in 1828, 7,707,427 lbs.,[120, 121] in 1832, 9,906,606 lbs., in 1837, 16,581,467 lbs., in 1840, 19,333,597 lbs.[122] In value the proportion of tea to the total American imports from China during these years was for 1822, 36%, for 1828, 45%, for 1832, 52%, for 1837, 65%, for 1840, 81%.[123] It can readily be seen from these figures that in the years following 1814 the relative proportion of teas to other Chinese imports constantly increased.[124] During these later years, in fact, our Canton commerce was mostly for the purpose of obtaining them. The teas thus imported came from nearly all of the southeastern provinces and from some of the central provinces of China.[125] The many bewildering grades known to trade were all subdivisions of the two main kinds, black and green, grown on different varieties of the same species of shrub.[126] Black teas, the cheapest, included such grades as Souchong,

---

[118] Hugh Murray, et alii, An Historical and Descriptive Account of China. 3 v., Edinburgh, 1836. 3: 50.

[119] Peter N. Snow, American Consul at Canton, wrote Feb. 15, 1836, that it still continued. Consular Letters, Canton, II. The statistics for 1836-7 in the Chinese Repository, 6: 284-6, also show it to have been still in progress.

[120] The figures before 1816 were, for 1790, 3,047,252 lbs., for 1794, 2,460,914 lbs., for 1800, 3,797,634 lbs., for 1805, 5,119,441 lbs., for 1810, 7,839,457 lbs. Pitkin, Stat. View, ed. 1835, pp. 246, 247.

[121] Pitkin, Stat. View of U. S., ed. 1835, pp. 246, 247, 301.

[122] Chinese Repos., 9: 191.

[123] Ex. Doc. 35, 27 Cong., 3 Sess., p. 10.

[124] This proportional increase was largely due to the decline in the importation of silks and cottons. Commerce of the U. S. with China, Hunt's Merc. Mag., 11: 55.

[125] These were Fuhkien, Nganhui, Kiangsu, Kwantung, Hunan, Hupeh, Honan, and Szechuen. Ch. Rep., 8: 135-148.

[126] Ibid.

Orange, Bohea, Congo, Campoi, and Pekoe. Of these Bohea and Souchong were the main ones purchased by Americans. Of the green teas, Hyson, Hyson-skin, Young Hyson, and Gunpowder were the main kinds.[127] In the years immediately after 1784, Bohea, the cheapest grade, was chief in American cargoes. Later, Souchong, a better black tea, began to predominate, and after 1800 the proportion of the still higher grades, green teas, especially Hyson, Young Hyson, and Hyson Skin, began to increase, until by 1810 green and black teas were imported in nearly equal amounts.[128] By 1837 the green teas were four-fifths or more of the total amount.[129] This steadily increasing demand in the United States for better grades of teas clearly indicates a growing discrimination of taste and an increasing ability to buy.

The exportation of teas from China in American ships, however, was not to supply the home market alone. There was a large shipment of teas to other countries, both directly from China and by reëxportation from the United States. During the European Wars the proportion reëxported had been large, usually a third of the year's imports.[130] After the War of 1812 the proportion declined to a fourth or even a tenth, largely because such teas as were taken to foreign countries in American ships could more easily be brought directly from China.[131] Some were taken to Russia,[132] some to France,[133] some to Gibraltar,[134] some to Brazil,[135] but more to Holland and to the German ports, principally Hamburg.[136] The American tea trade in Holland fell off

[127] Murray, Histl. and Descriptive Acct. of China, 3: 52.

[128] Consular Letters, Canton, I (estimates by the American Consul), and Impost Books of the Providence Custom House, passim, are the best authorities. The amounts are also shown by the tables in Pitkin, Stat. View, ed. 1816, p. 209.

[129] Ch. Rep., 9: 191.

[130] Pitkin, Stat. View, ed. 1836, pp. 246-247.

[131] Ibid.

[132] Pitkin, Stat. View, ed. 1816, p. 195.

[133] Parl. Papers, 1821, 7: 381-382. Table prepared by Trumbull Bros. and Co., of imports to Marseilles. See British Relations with Chinese Empire, p. 28, for French Atlantic Ports.

[134] British Relations with Chinese Empire, p. 28.

[135] Ibid.

[136] The amounts in 1826, rather a banner year, were, Holland, 230,137

in later years, as the Netherlands finally began to import for themselves.[137] Canada got her teas largely from the United States, in spite of the higher import duties in the latter country,[138]

Spanish dollars, Gibraltar, 235,474, Hanse Towns and Germany, 337,331, France on the Atlantic, 209,252, the Brazils, 180,164, all others, 216,336. Ibid. The "Brookline" came to Hamburgh with teas in 1834. Ms. log of "Brookline." Parl. Papers, 1821, 7:84, Evidence of Robert Richards.

[137] Report of Select Com. on E. India Co., Parl. Papers, 1830, 5: xix-xx.

[138] This is perhaps a good place to sketch in a footnote the history of the United States tariff on China goods to 1844. Various individual states had levied a tariff on tea before the adoption of the Constitution (South Carolina's tariff is given in the Providence Gazette, May 29, 1784. Pennsylvania's tariff is mentioned by Fitzsimmons in a speech on the tariff, Apr. 18, 1789, Benton's Abridg., 1:42) and in 1789 in the first tariff passed by Congress, it was one of the luxuries which had had an impost duty put on it, a duty, however, which discriminated sharply in favor of American ships and of voyages made directly from China. (The Public Statutes at Large of the United States of America, 1:25. The debates are in Benton, Abridgement, 1:42, 41.) There was some opposition to the heavy discrimination, and in the tariff of 1790 this was made less pronounced, duties on teas brought in American ships being raised to be more nearly equal to those brought in foreign vessels. (U. S. Statutes at Large, 1:180.) The reduced protection led to a larger influx of teas from Europe and to much dissatisfaction among the merchants engaged in the China trade. (Report of Hamilton on trade with India and China, Feb. 10, 1791, American State Papers, Finance, 1:107. Petition of Philadelphia merchants, Feb. 24, 1792, Annals of Congress, 2d Cong., p. 427. Petition of Boston Merchants, June 7, 1797, Annals of Cong., 5th Cong., Vol. 1, p. 251.) The next year, 1791, the policy was adopted of allowing the payment of duties on teas to be postponed by a bonding process, a plan which thirty-five years later was to prove so disastrous in the case of Thomas H. Smith and others. (U. S. Stat. at Large, 1:219, 1:627-704, 168.) No other general schedule was adopted until 1816, but in the meantime a few changes had been made. January 29th, 1795, a specific rate was made for gunpowder, imperial, and gomee teas. (U. S. Stat. at Large.) March 3d, 1797, an additional duty was levied to pay the foreign debt (U. S. Stat. at Large, 1:503); March 24th, 1804, an additional duty of two and a half per cent ad valorem was imposed to help defray the expenses of the war against Tripoli and the Barbary powers (Ibid., 2:291), an act which was continued from time to time until 1813 (Ibid., 2:391, 456, 511, 555, 614, 675); and a slight change was made, also in 1804, on duties on cassia, gunpowder, mace, and nutmegs. (Ibid., 2:299.) In 1812, as a war measure to raise revenue, all duties were increased one hundred per cent with an additional

and continued to do so until 1825, when the East India Company was permitted to ship tea directly to the Dominion.[139]

Tea was the most important American export from Canton, but there were others which were prominent for many years. Chinese silk was always exported, generally in a manufactured form. In the fifteen years after 1820 it was of great importance, several times amounting to more than one-third of the total imports to the United States from China.[140] Later, however,

---

ten per cent on goods not imported in vessels belonging to citizens of the United States, the increase to cease with the conclusion of peace. (Ibid., 2: 768.) The tariff of 1816, the first general one since 1790, raised the duties on China goods over those of the earlier year from twenty to forty per cent, still preserving a discrimination in favor of those brought in American bottoms directly from Canton. The protective tariff wave affected the duties on these goods, and in 1824, for the first time, an import tax of twenty-five per cent ad valorem was placed on cotton and silk manufactures from beyond the Cape of Good Hope. Two exceptions, however, were made in favor of the China merchants; the provisions of the law were not to apply until January 1st, 1825, and nankeens were not included in the rule which considered the minimum cost as thirty cents a yard. (Ibid., 4: 25.) The "Tariff of Abominations" (May 19, 1826) affected the China trade merely in the one item of an additional five per cent ad valorem on all silks from beyond the Cape of Good Hope. (U. S. Statutes at Large, 4: 270.) In 1830 the duties on teas were reduced materially (Ibid., 4: 404), and the tariff of 1832 for the first time entirely exempted from duty teas brought in American vessels directly from East Asia, and reduced the duty on most of the other China goods. At the same time the law permitting the deposit of teas under bond was repealed, bringing to an end a system which had been begun forty years before. (Ibid., 4: 583.) The tariff of 1841 still exempted from duty tea brought by American ships from China, although levying one on other China goods (Ibid., 5: 463), but with a brief revival of higher tariff legislation in the act of 1842, a thirty per cent ad valorem duty was placed on China ware, a specific duty on cassia, mace, and ginger, and a twenty per cent ad valorem duty on all unenumerated goods, an increase which must have included teas and silks. A ten per cent additional duty was placed on all goods imported from the East. (Ibid., 5: 548.) The tendency of the long discrimination in favor of American ships was to keep the China trade in the hands of American shippers, a protection, however, which was scarcely needed, so efficient was the merchant marine.

[139] Report of Select Com. on E. India Co., Parl. Papers, 1830, 5: xix-xx, and Sen. Doc., 1 Sess., 19 Cong., No. 31.

[140] Tables in Pitkin, Stat. View, 1835, p. 301. Ex. Doc. 35, 3 Sess., 37 Cong., p. 10.

owing possibly to changing fashions, it declined, until in 1841 it was scarcely eight per cent of the whole.[141] Somewhat similar were the cotton cloths or nankeens. Although bearing the name of Nanking, they were manufactured in many other parts of China. They were white, blue, or brown, and "in point of strength, durability, and essential cheapness" were not surpassed by any of the cotton fabrics of Europe or England.[142] In point of value they never exceeded fourteen per cent of the total American imports from Canton, and for the most part were much less. Like silk, they suffered a great decline before 1839, sinking from $452,873 in 1829[143] to $2,363 in 1840.[144]

Other articles of importance were cassia, a substitute for cinnamon, which seldom amounted to more than $100,000 a year in value,[144] china ware, used often as ballast, but in later years driven out of the American market by European porcelain,[145] a little sugar, principally in the form of sugar candy,[146] and numbers of minor articles such as fire screens, firecrackers, camphor, rhubarb, and fans.

Like teas, these other articles were brought in American ships not only to the United States, but also to many other parts of the world. Silks, said to have been manufactured by the Chinese in imitation of French goods, were exported to South America.[147] Nankeens were also taken there, and quite an extensive trade was carried on with that continent, contraband during the earlier years, legal after the independence of the South American republics.[148] Various other China goods were,

[141] Ex. Doc. 35, 3 Sess., 17 Cong., p. 10, and Lecture of Sturgis, Niles Register, 68:343.

[142] Murray, Histl. and Desc. Acct. of China, 3:56. Ch. Rep., 2:465.

[143] Pitkin, Stat. View, ed. 1835, p. 301.

[144] Ex. Doc. 35, 27 Cong., 3 Sess., p. 10.

[145] Ibid., and Hunt's Merc. Mag., 3:469, Ch. Rep., 2:455-456.

[146] Ch. Rep., 2:471.

[147] Voyage autour du Monde, Executé pendant les années 1836 et 1837 sur la Corvette La Bonite. Relation du Voyage par A. De La Salle. 3 v., Paris, 1852. 3:238.

[148] Weeden, Oriental Trade of Providence, p. 263, mentions the "Arthur" as attempting to take nankeens to Montevideo and Rio Janeiro in 1809. Forbes, Personal Reminiscences, pp. 98-111, mentions smuggling on the west coast of South America in 1825, and running the blockade into Buenos Ayres in 1827.

of course, taken to the countries where tea was imported, although not to so large an extent.[149]

During the years following the War of 1812 the peculiar community life which grew up at Canton under Chinese regulations took on its completed form. Americans had long since won their place among the foreign merchants and were second in influence and importance only to the English. The American factory was one of the best in the thirteen,[150] but business had outgrown it and had overflowed into other hongs. The American firms were mostly commission houses, often closely allied to firms in the United States, but organized separately and under different names. Of the one hundred and thirty-three foreign residents at Canton, Macao, and Lintin, in 1832, twenty were Americans,[151] and by 1841 the number had increased to thirty-seven.[152] Of these American firms, the earliest was Shaw and Randall, and the most famous were Milner and Bull, Talbot, Olyphant and Company,[153] Samuel Russell and Company (1818-1823)—which was succeeded by Russell and Company (1823-1824)[154]—Russell, Sturgis, and Company (? -December 31, 1839),[155] P. W.

[149] Parl. Papers, 1821, 7: 381, 382, give an account of nankeens brought into Marseilles in 1817 and 1818, and Parl. Papers, 1833, E. India Co. Papers, relating to trade with India and China, p. 14, give the exports from Canton in American vessels destined for other places than the United States.

[150] In 1838 the chaplain of the frigate "Columbia" described it as "an extensive building, three stories high, fronting the grounds on the river, and extending back for some three or four hundred feet, with an open passage way or narrow court running through its center from the front to the back walls. The building is divided into three compartments. . . . Within this range of walls are the store rooms, and rooms occupied by the comprador, coolies, and other servants attached to the hong, comprising the . . . . ground floor, and the second story affording fine drawing rooms and chambers, both spacious and airy, two requisites for comfort in this climate. The top of the building is crowned by a turret . . . . from which an extensive view is had." Taylor, Flagship, 2: 170. See as well a description in Paullin, Diplomatic Negotiations of American Naval Officers, pp. 171-173.

[151] Roberts, Embassy to Ern. Courts., p. 130.

[152] Chinese Rep., 10: 58-60.

[153] Griffis, America in the East, p. 71.

[154] Hunter, Fan Kwae in Canton, pp. 156, 157.

[155] Canton Press, Jan. 25, 1840.

Snow,[156] J. P. Sturgis,[157] and Wetmore and Company.[158] The names of these firms remained the same from year to year but their composition changed.[159] As a rule they were made up of specialists, men who had come out to China in early life and had learned the business from the bottom up.[160] Although the American trade was not a government monopoly, it became almost a natural one, for the experience required made it difficult for a new firm to succeed unless closely allied to some older one.

As was natural in such a compact group of foreigners there was much community life. In 1836 the Canton General Chamber of Commerce was formed to secure united action in protecting the interests of foreign trade.[161] Various missionary and philanthropic associations were organized. Newspapers were started; the "Canton Register" was begun in 1827 by some Englishmen, with Mr. Wood, a young Philadelphian, as editor; "The Chinese Courier and Canton Gazette," an American enterprise, published its first number July 28, 1831, but created opposition by its independent position on British questions and did not live long; and "The Canton Press" was started in 1835.[162] Social activities, too, were not neglected. In 1837 the "Canton Regatta Club" was formed, much to the mystification of the practical-minded hong merchants.[163] There is occasional mention of formal dinners in which national lines were forgotten.[164] Most of the social life, however, was at Macao. There the

---

[156] Chinese Rep., 5:431.

[157] He arrived in 1809 and was in business in China for twenty-five years. Bits of Old China, Hunter, pp. 157-161.

[158] Chinese Repository, 5:431.

[159] Hunter, Fan Kwae at Canton, pp. 156, 157, gives the history of Russell and Company, which shows this statement to be true. Also see Canton Press, Jan. 25, 1840, and Canton Register, Jan. 3, 1831.

[160] See as an example, sketch by Hunter of his own life there from 1824 to 1842 in his Fan Kwae at Canton, p. 1.

[161] Anglo-Chinese Kalendar for 1838, Canton, 1838. Eitel, Eur. in China, p. 67, and Chinese Rep., 6:44-47. The Chamber of Commerce comprised representatives from all foreign nationalities doing business in Canton.

[162] See Bibliography.

[163] Hunter, Bits of Old China, p. 276.

[164] Nye, Morning of My Life in China, p. 55, mentions a farewell dinner in 1838 to Mr. Jardine, at which one hundred British and American merchants were present. Ch. Rep., 11:1, mentions a somewhat similar dinner in 1832.

Chinese restrictions were somewhat relaxed, and the greater leisure of out-of-season months gave more time for recreation. The little peninsula was a bit of the West, a Portuguese colony, and during the winter months it would have been difficult to discover a gayer society anywhere short of Europe.[165]

On the part of the United States Government the years following the War of 1812 were ones of gradually increasing interest in China. We have seen that it was one of the factors of the Oregon agitation in Congress. In addition to this, in March, 1822, the House committee on commerce took occasion in its report to notice the importance of the American trade in China: "It is inferior to that of no nation, Great Britain excepted."[166] In November, 1819, the frigate "Congress," the first of the United States navy to visit the port, anchored off Lintin. She was tolerated by the Chinese as a convoy to merchant ships, but was ordered "not to linger about on the coast" after the merchantmen had sailed.[167] She stayed on, however, with two absences of some months, until early in 1821. The Chinese after some protest allowed her to take on supplies.[167] In 1830 the "Vincennes," the first American ship to circumnavigate the globe, called at Macao. Early in 1832 the frigate "Potomac" visited Canton after having punished the natives at Quallah Battoo in Sumatra for the plunder of the ship "Friendship" of Salem the year before. The consul was ordered to "compel her to set sail and to return to her own country."[168] In 1832 the expedition of Edmund Roberts, composed of the ship "Peacock"

---

[165] Occasional references to this society occur in various narratives, and the journal of a Salem girl who spent four years there (1823-1833) gives us an intimate picture of this gay Occidental life in its Oriental setting: My Mother's Journal, A Young Lady's Diary of Five Years Spent in Manila, Macao, and the Cape of Good Hope, from 1829-1834, Katherine Hillard, editor, Boston, 1900. See also on Macao, Letters and Recollections of J. M. Forbes, 1: 82, and for a description of the place, Missionary Herald (article by S. W. Williams), 35: 52-55, Milburn, Oriental Commerce, p. 451, Shaw's Journals, pp. 236-241, La Perouse, Voyages, 2: 280-285.

[166] Am. State Papers, Commerce and Navigation, 2: 637.

[167] Niles, Register, 19: 74. Paullin, Diplomatic Negotiations of American Naval Officers, pp. 168-181.

[168] Reynolds, Voyage of the Potomac, pp. 343-344, Ch. Rep., 11: 9, 10.

and the schooner "Boxer," was sent out by the United States to secure treaties with eastern powers, and to protect the interests of American seamen. Its immediate cause was the "Friendship" affair, but it visited Manila, Canton, Cochin China, Siam, and Muscat, and secured treaties with the last two. It touched at Canton in November, 1832, but of course could not get into communication with the government, and was ordered to leave at the earliest possible moment.[169] Four years later Roberts returned to the Far East in the "Peacock" to exchange ratifications. Again the expedition touched at Macao. It was watched closely by cruisers and was ordered to leave as soon as its sick were well.[170] In the interval between Roberts' two visits the "Vincennes" had again been there and had met with the usual peremptory order to leave.[171] The Roberts embassy was a sign of an awakening interest on the part of the government. Jackson himself mentioned the China and East India trade in his annual message of December, 1831.[172] Under the same vigorous administration an exploring expedition was sent out to the South Seas under Commodore Wilkes, with the revival of the *beche de mer,* sandal wood, and sealing voyages prominent among its objects.[173]

---

[169] Roberts, Embassy to Eastern Courts, passim, Ch. Rep., 11:11; January, 1842. Secondary accounts are in Foster, Am. Dip. in the Orient, pp. 45-55, and Callahan, Am. Relations in the Pacific, 11:48.

[170] Ruschenberger, Voyage Round the World, p. 374. Ch. Rep., 5:228. Sept., 1836.

[171] Canton Register, 9:9. (1836.) The Hoppo's order was dated Jan. 9, 1836.

[172] James D. Richardson, A Compilation of the Messages and Papers of the Presidents, 1789-1897, Washington, 1900. 2:551.

[173] It was first planned for 1827 and 1828 (Fanning, Voyages to the South Seas, p. 172), but it was given up by the new administration, and was not authorized until 1836. (Fanning sent in memorials to Congress in the latter part of 1833. Fanning, Voyages to the South Seas, pp. 152-167. Reynolds, Address.) It sailed in 1838 after more delay, and was gone until 1842. (Wilkes, Narrative of U. S. Exploring Exped. during the years 1838-1842, gives the account. Callahan is in error in saying that it was from 1839 to 1841. Callahan, Am. Relations in the Pacific, p. 11.)

CHAPTER IV.

From the Close of the War of 1812 to the Outbreak of the Opium Troubles, 1815-1838 (*Continued*).

THE BEGINNINGS OF AMERICAN MISSIONS TO THE CHINESE.

In their origin American missions were singularly distinct from American commerce. In Portuguese, in Spanish, and in French intercourse with non-Christian lands the trader and the missionary have usually gone together. The same has been true in British and in Dutch enterprises, although to a more limited extent. Christian missions have either begun simultaneously with commerce, conquest, or exploration, or have been directed to those countries to which these had pointed the way, as in the Americas, in India, in the Philippines, and in the Dutch Indies. In the early decades of missions from the United States, however, no such relationship obtained. Americans had abundant commerce with non-Christian lands, but their earliest foreign missions were not directed to those peoples with whom they had the largest trade.

This anomalous situation was due to the causes which brought about the American foreign missionary enterprise. One is impressed with the fact that in the United States missions arose largely because of the stimulus of Great Britain's example. The last decade of the eighteenth century saw in England a great awakening of missionary interest. The English Baptist Missionary Society was formed in 1792, the London Missionary Society in 1795, the Scotch Missionary Society in 1796, and the Church Missionary Society in 1800.[1] The effect of this movement was quickly felt in America. Worcester says: "After the London Missionary Society was formed in 1795, the appeals of Christians in England had an electrical effect upon our churches. Missionary publications awakened an interest which in our present circumstances it is difficult to appreciate."[2] When in 1797 the General Association of Connecticut talked of organiz-

[1] The Christian Observer, 40: 309.

[2] S. M. Worcester, Origin of American Foreign Missions, p. 8, in H. W. Pierson, American Missionary Memorial, New York, 1853.

ing a missionary society[3] it said in its public appeal: "Among the numerous inducements to attempt this important object . . . . we mention the uncommon success God has been graciously pleased to grant to late undertakings of this kind in Great Britain and the United States." The formation of the Philadelphia Bible Society in 1808 was due to its founders "contemplating with unfeigned pleasure the extensive good doing by such a society in Great Britain."[4] The American Bible Society was so closely allied with the British and Foreign Bible Society that the latter's annual reports included for a time accounts of the work of the former.

The first American missionary societies did their work on the frontiers and among the Indians, and although foreign work was among the objects of one of them, the Massachusetts Missionary Society,[5] it was not undertaken until the formation of the American Board of Commissioners for Foreign Missions, in 1810. This organization, it is true, was the direct outgrowth of the missionary purpose of a little band of students which existed first in Williams College and later in Andover Theological Seminary, and whose request to be sent out to the foreign field led to the formation of a society for that purpose[6]; but here again British example prepared the way. Missionary papers had been full of the work of the English societies,[7] and English missionaries had corresponded with American church leaders.[8] The

[3] Address of the General Association of Connecticut to the District Association on the subject of a Missionary Society, etc., Norwich, 1797.

[4] The Panoplist and Missionary Magazine, Boston, 1809-1817. N. S., 1:377 (1809). (For 1818, 1819, and 1820 this paper was called The Panoplist and Missionary Herald; beginning with 1820 it was called the Missionary Herald.)

[5] This society was formed in 1799, and had at once come into fellowship with the London Missionary Society. Worcester, Origin of Am. For. Missions, p. 9.

[6] Worcester, Origin of Am. For. Missions, pp. 15-22. Panoplist, and Missny. Mag., N. S., 5:228.

[7] Annual Report of the Director of the N. Y. Missny. Soc., 1804, speaks of the work of the London Missionary Society. In the Panoplist, N. S., 2:568-571, May, 1810, some letters from William Carey from India were published, and in the same, 3:277, some news from Otaheite were given.

[8] Letters from William Carey to Rev. Miller, N. Y., Nov. 30, 1809. Panoplist and Missny. Mag., 2:568-571.

first plan of the American Board was to work in conjunction with the London Missionary Society, and in 1811 Adoniram Judson was sent to England to see if the latter organization would give financial support, to arrange the relations between the societies, and to obtain information about prospective fields and missionary preparation and administration. The English Society was cordial, but felt that mutual independence was preferable, and the Americans later came to the same conclusion.[9] The American Board's first missionaries, Rice, Nott, Hall, Judson, and Newell, were drawn closely to their English brethren in India, and its first large stations were there. The American Baptist Board of Foreign Missions, formed in 1814, and the Episcopal and the Methodist societies, formed in 1820, were influenced by the example of the earlier organization, and if not daughters were at least granddaughters of the English societies.[10]

In view of this early relationship between English and American missionary enterprises it was but natural that the first American missionary efforts among the Chinese should be largely a result of British influence, and only incidentally of American commercial relations. The first Protestant worker resident in China, Robert Morrison, was a representative of the London Missionary Society. He arrived in Canton in September, 1807.[11] In 1812 he was joined by Rev. William Milne of the same society, who later settled at Malacca and was instrumental in founding

[9] Original letters and a nearly contemporary account are in the Panoplist and Missny. Mag., N. S., 4: 178-185.

[10] It must not be thought, however, that British example was the only cause of American missions. It was the immediate one, but it found a ground ready for its seed. Much the same forces acted as in England. Americans had ceased to turn their eyes inward and had begun to have a world view. Trade had an indirect effect by bringing a knowledge of the peoples of distant lands, and the quickened religious life produced by the Wesleyan and kindred movements of the eighteenth century had prepared the churches for action.

[11] Memoir of Morrison, 1: 91 et sqq. Samuel Wells Williams, The Middle Kingdom, New York, 1904, 2: 316-322. See too Carl Friedrich August Gützlaff, Geschichte des Chinesischen Reiches, von den ältesten Zeiten bis auf den Frieden von Nanking, Karl Friedrich Newmann. editor, p. 785.

the Anglo-Chinese College in that place.[12] By 1828 he had finished his translation of the Old and New Testaments[13] and had made his first convert, Leang Afa. Rev. W. H. Medhurst and Samuel Dyer had joined him, the former working in Batavia[14] and the latter at the Straits Settlements.

From the very start Morrison was closely connected with the United States. Because of the unfriendliness of the East India Company he sailed from New York on an American ship, and was given a letter of introduction by Madison, then Secretary of State, to Carrington, the United States Consul at Canton.[15] On his arrival in China he lived for a year in the American hong with the New York firm of Milner and Bull.[16] Frequent news of Morrison and other workers among the Chinese appeared in the American missionary publications[17] and American contributions helped to publish the Serampore translation of the Bible.[18] In 1824 the American Tract Society called attention in its report to Milne's need of tracts for distribution among the Chinese.[19] In 1820, Morrison was elected, "by ballot to be corresponding member" of the American Board,[20] and in 1821 the American Bible Society presented him with a Bible in admiration of his services.[21] As time went on, Morrison and Milne became eager to have the American churches join in the enterprise[22] and to have either America or England send out a chaplain for the seamen at Whampoa.[23] These views became known in the United States and found a ready response. The Missionary

---

[12] Robert Philip, The Life and Opinions of the Rev. William Milne, D.D., Missionary to China, Philadelphia, 1840. Williams, Mid. King., 2: 318-322.

[13] The New Testament was completed in 1813 and the Old Testament in 1819. Philip, Life and Opinions of Milne. Foster, Christian Progress in China, pp. 40-45.

[14] William Dean, The China Mission, New York, 1859, p. 85.

[15] Morrison, Memoir, 1: 91, 129, 131.

[16] Ibid., p. 153. Williams, Mid. King., 2: 318-322.

[17] Panoplist, 3: 381, 421, N. S., 3: 372; 11: 37, 549; 17: 265; 19: 158; 20: 56; 21: 56.

[18] Panoplist and Missny. Mag., N. S., 5: 168.

[19] Proceedings of the first Ten Years of the American Tract Society, Boston, 1824, p. 143.

[20] Memoirs of Morrison, 2: 83.

[21] Memoirs of Morrison, 2: 116.

[22] Philip, Life and Opinions of Milne, p. 128.

[23] Extract from Milne's Retrospect of the first ten years of the Protestant

Herald in October, 1828, in speaking of Morrison said: "No sufficient reason exists why he should not be strengthened by other laborers or why the churches of this country should not send them."[24] The American Seaman's Friend Society, in its report of 1829 called attention to "the three thousand American and English seamen who annually visit the port of Canton, China," and "determined to occupy Canton as soon as a suitable person presents himself for the service."[25] The initial step was taken by D. W. C. Olyphant, an American Canton merchant, who had become acquainted with Morrison some years before,[26] and who was so deeply interested in missionary projects that his rooms in Canton had come to be known as "Zion's Corner."[27] He offered to give free passage and a year's residence to any missionary whom the American Board should send.[28] As a result both the American Seaman's Friend Society and the American Board bestirred themselves and each succeeded in finding a man. The two, Rev. David Abeel and Rev. Elijah C. Bridgman, were sent out in October, 1829, and arrived at Canton in February, 1830.[29] The former, a minister of the Dutch Reformed Church, was to serve one year as chaplain of the American Seaman's Friend Society, and was then to enter the service of the American Board and to examine the Eastern waters for the best localities for missionary work. Bridgman went out directly under the American Board, and was to devote his time to Canton.[30] This dual plan had been suggested two years before by several Americans in Canton[31] and was now carried out.

Mission to China, in Missny. Herald, 17:265. Abeel and Bridgman were sent out as a direct result of Morrison's wish. 2d Annual Report (1830) of American Seaman's Friend Society, New York.

[24] Missny. Herald, 24:330 (Oct., 1828).

[25] First Annual Rep. (1829) Am. Seaman's Friend Soc., p. 17.

[26] Memoirs of Morrison, 2:86.

[27] Hunter, Bits of Old China, p. 166.

[28] Abeel, Journal, pp. 31-32. Foster, Am. Dipl. in Orient, p. 137, footnote, is in error in saying: "Upon his [Olyphant's] invitation the first Protestant missionary, Robert Morrison, of England was brought to China." but he is fairly correct in his other points.

[29] Abeel, Journal, pp. 31-33. Bridgman, Life of Bridgman, pp. 1-37. Williamson, Memoir of Abeel, pp. 49-67.

[30] Ibid.

[31] First Annual Report of American Seaman's Friend Soc., May, 1830, p. 36.

In the work thus begun by the American churches there were two factors which determined the line of approach and the method of work. In the first place, the Chinese Empire was practically closed to all but the most limited missionary work. The Roman Catholics held their own, but with the greatest difficulty, chiefly because they had gained a foothold in China in more favorable days. The Protestants were confined to Macao and to the little spot in Canton accessible to foreigners. Even here imperial edicts threatened with strangulation any one who should attempt to propagate Christianity, and the work had to be carried on with more or less secrecy.[32] Work was largely confined to language study and to translation. A few years later it was found possible to distribute printed matter along the coast to some extent, but even by this means no large numbers could be effectively reached until China should be opened.

A second factor was the presence outside the Empire of large numbers of Chinese colonists. In Siam, in the Malay Peninsula, and in the Archipelago, large settlements of Chinese existed which were easily accessible to missionary influence. Here was an opportunity to learn the language, to print books, to found schools, and to do preliminary work until the Empire might be opened, and here also was the chance to do an extensive work among a Chinese population both for their own sakes and in the hope that some of them might be converted and return to China to spread the faith.

These two factors early divided American Protestant missions to the Chinese into two branches, those in Canton and those to colonists outside the empire. The first branch must again be subdivided into missions inaugurated from America and those started by foreign residents of Canton. We have already seen the beginning of the missions inaugurated from America and centering at Canton, and it remains to trace them down to the outbreak of the opium troubles. Bridgman and Abeel arrived in China in February, 1830. They took up their residence, according to Mr. Olyphant's agreement, with Talbot, his representative.[33] Morrison, who had done so much to bring about

[32] Chinese Repository, 6:53, gives the new edict of 1821 against Christians.

[33] Talbot was also American Consul. David Abeel, Journal of a Resi-

their coming, gave them every assistance. Abeel took up his duties as chaplain both to the American residents and the foreign seamen, in Canton, and was kept too busy for language study or for work among the natives.[34] He preached in the large room of the factory where he resided, and when occasion offered, on the ships in the harbor at Whampoa.[35] In December he closed his year's work and left for Batavia on a tour of investigation for the American Board. Bridgman spent the year mostly in language study, but he found time for teaching a few boys, and for preaching and correspondence. By the end of the year he had also prepared some Scripture lessons in Chinese.[36]

Most of 1831 passed without event. Bridgman and his little school spent the summer at Macao.[37] A press was sent out in the latter part of the year by Olyphant's church in New York,[38] and on its arrival and at the suggestion of Morrison and others, Bridgman determined to start a periodical.[39] This, the Chinese Repository, was as its title suggests, begun for the spread among foreigners of information concerning China, its laws, customs,

---

dence in China and the Neighboring Countries, New York, 1836, pp. 61-74. Correspondence of the American Board of Commissioners for Foreign Missions, Mss. in their Library in Boston. Letter of Bridgman to Jer'h Evarts, Mar. 5, 1830. The date on the letter is Feb. 5, but other documents prove this to have been a slip of the pen.

[34] Abeel, Residence in China, p. 105.

[35] Ibid., pp. 105-106, and 3d Annual Rep. of Am. Seaman's Friend Soc., p. 3.

[36] Correspondence of the A. B. C. F. M., in China, Nos. 21, 35, 37, 41. (Letters and Journal of Bridgman.) Abeel, Residence in China, p. 151. The Life and Labors of Elijah Coleman Bridgman, edited by Eliza J. Gillett Bridgman with an introductory note by Asa D. Smith. New York, 1864, pp. 43-57.

[37] Corres. of A. B. C. F. M., China, 1831-7, No. 44. Bridgman to Evarts, June 13, 1831.

[38] Morrison had wished a press sent out with the American mission in the first place. Letter from him in Missny. Herald, 26:366. Frederick Wells Williams, The Life and Letters of Samuel Wells Williams, LL.D., Missionary, Diplomatist, Sinologue, New York, 1889. Letter of Williams, p. 78. The press arrived in December, 1831, and the type came months later. Corres. of A. B. C. F. M., China, Nos. 53, 60, letters of Bridgman, Dec. 30, 1831, and Apr. 18, 1832.

[39] Corres. of A. B. C. F. M., China, No. 60, and Bridgman, Life and Letters of Bridgman, p. 74.

history, and current events, and concerning missions to the Chinese. It was put in a form designed to make it of interest to the reader not primarily concerned with religious matters.[40] It was begun in May, 1832,[41] and for the first year or two was the source of much anxiety to Bridgman. He feared that the American Board would not approve of it[42] and that it would not be a financial success. It was undertaken for the first year by the Christian Union of Canton, a local organization, but Bridgman wrote in April, 1833, that it could not "be carried forward without considerable expense and against many difficulties."[43] Later, probably in January or February, 1834, Olyphant came to the rescue, guaranteeing the expense and furnishing a building which housed the magazine for over forty years.[44]

The same year in which the Repository was begun saw the arrival at Canton of a successor to Abeel, Rev. Edwin Stevens.[45] He reached China in June, the first of those Yale graduates who were later to have so large a part in missions to China. He continued his work for four and a half years, the last nine months being in the service of the American Board. He died January 5, 1837, while on a trip to Borneo.[46] The chaplaincy to the sea-

---

[40] It continued to be published long after 1844, and is one of the best sources for the history of the foreign relations of China throughout this period. Bridgman remained its editor until 1851. Bridgman, Life and Letters of Bridgman, p. 74.

[41] Ibid.

[42] Corres. of A. B. C. F. M., China, 1831-7, Bridgman to Anderson, Jan. 19, 1833, "I am very anxious to know what you think of the Repository. Shall it go on?"

[43] Ibid., No. 73.

[44] Corres. A. B. C. F. M., China, 1831-7, No. 89, Bridgman to Anderson, Feb. 4, 1838. The letter told of Olyphant's offer, and concluded: "The expense of the first volume will be something to him,—perhaps and perhaps not,—but for the second we hope there will be no charge, for a little extra work we intend that the office shall pay for itself." S. W. Williams was not quite exact when he wrote that "when the Chinese Repository was commenced he [Olyphant] offered to bear the loss of its publication, if it proved a failure." (Williams, Life and Letters of S. Wells Williams, p. 78.) The guarantee, although including the first volume in its scope, was not made until later.

[45] Ch. Rep., 1 : 243.

[46] Alexander Wylie, Memorials of Protestant Missionaries to the Chinese,

men left vacant by him was never filled. Rev. J. W. Newton accepted the place, but seems not to have taken up the work,[47] and the American Seaman's Friend Society, which had joined in beginning the American Mission to China, disappeared from the field.[48]

In 1833, perhaps partly in response to an appeal which Morrison and Bridgman had made in 1832,[49] two more men arrived, Samuel Wells Williams, and Rev. Ira Tracy. Williams came to take charge of the press, and Tracy as an additional missionary. They sailed from the United States in 1833 on one of Olyphant's ships, the "Morrison," and arrived in China in October.[50] Tracy left Canton soon afterward to be stationed at Singapore.

In 1834 the growing mission at Canton received a serious check. Leang-Afa, the first Chinese convert, together with a fellow disciple, had been distributing many Christian books in and around Canton.[51] In that year Lord Napier, the first British superintendent of trade, reached Canton, and trouble arose which resulted in the Chinese stopping the English trade. Napier, failing to make an impression on the governor, issued a printed proclamation to the Chinese people—an indiscreet act for a diplomatist—in which he stated his case. This angered the authorities and search was made for the natives who had helped to publish the appeal. The mission's printing office was raided, Leang-Afa and several other Chinese were seized, and although released later, felt it best to leave the city for a time.[52] The disorders had already frightened away Bridgman's Chinese teacher and pupils,[53] and this added trouble, together with the death of

---

Giving a list of their Publications and Obituary notices of the Deceased. Shanghai, 1867, p. 84, and Ch. Rep., 5: 513.

[47] 9th Annual Rep., Am. Seaman's Friend Soc.

[48] Up to 1844, as their annual reports show, they had obtained no successor to Stevens who actually reached the field.

[49] Corres. of A. B. C. F. M., China, 1831-7, Sept. 4, 1832.

[50] Williams, Life and Letters of S. W. Williams, p. 49, Corres. of A. B. C. F. M., China, 1831-7, No. 78, Bridgman to Anderson, Oct. 22, 1833.

[51] Missny. Herald, 30: 192; 31: 70.

[52] Williams, Mid. King., 2: 328, and Joseph Tracy, History of the American Board of Commissioners for Foreign Missions, Worcester, 1840, p. 246.

[53] Corres. of A. B. C. F. M., China, 1831-7, No. 10, Bridgman to Anderson, Aug. 12, 1834.

Morrison, cast a gloom over the scanty force and retarded its work.[54]

While the after swells of this squall were dying down, there arrived still another reënforcement, Peter Parker, the first medical missionary to China. Bridgman had felt the lack of such a man for some time.[55] Morrison and T. R. Cooledge had each begun dispensing medicines in 1827,[56] but something more was needed, and to supply it, the American Board sent out Parker.[57] He sailed June 3[58] in one of Olyphant's ships and reached Canton October 26th.[59] It was early decided that he should go to Singapore to learn the language, and after a year there he returned to Canton. Here, November 4, 1835, he opened an Ophthalmic Hospital.[60] The suspicions of the Chinese were soon disarmed, and after the first year, Howqua, the chief hong merchant, gave him a building rent free.[61]

Five days before this hospital was opened, Stevens returned from a remarkable voyage with Medhurst along the coast of China. In the closed condition of the Chinese Empire it was possible to do little more than to distribute printed matter and to trust to it for the work of evangelization. From June, 1831, to May, 1832, Gützlaff, a German missionary, had made three

---

[54] Ibid., No. 102, Oct. 31, 1834, Bridgman to Anderson.

[55] Corres. of A. B. C. F. M., China, 1831-7, No. 83, Bridgman to Anderson, Dec. 26, 1833. He desires that Tracy's place at Canton be occupied immediately by an able physician. ". . . . all of us are anxious that such a man should be here."

[56] Williams, Mid. King., 2: 333.

[57] Stevens, Life of Parker, pp. 5-99.

[58] Parker was a New Englander by birth, and had been educated at Amherst and Yale, taking his A.B. at the latter institution in 1831, and later completing a medical and theological course there. While a senior in college he had decided to enter the mission field and had become a warm friend of Stevens. In 1834 he was ordained. Wylie, Memorial of Prot. Missionaries.

[59] Ibid. and Corres. of A. B. C. F. M., China, 1831-7, No. 173. Parker to Anderson, Oct. 30, 1834.

[60] George B. Stevens, The Life, Letters, and Journals of the Rev. and Hon. Peter Parker, M.D., etc., Boston and Chicago, 1896, pp. 106-119. A. P. Stokes, in Memorials of Eminent Yale Men. New Haven, 1914.

[61] Williams, Mid. King., 2: 333-7.

voyages along the coast, selling and distributing religious and scientific works.[62] Much criticism, however, was raised in some quarters by the fact that at least one of these voyages had been in connection with the opium traffic.[63] Still there was felt to be a larger opportunity here, and the missionary world was stirred to action by the German's reports. In the summer of 1835, Medhurst, who had been working among the Chinese in Batavia, came to Canton at the request of Morrison (through the London Missionary Society) to undertake a similar voyage. Through the agency of Olyphant and Company, he succeeded in obtaining the American brig "Huron," Thomas Winsor, master,[64] and took Edwin Stevens with him. They left August 26th, and by October 31st had visited the provinces of Shantung and Fuhkien, whose dialects Medhurst could speak, and the port of Shanghai. In Shantung they were able to travel overland some distance, meeting with only occasional resistance; but at Shanghai they were rudely received and were followed down the coast by war junks.[65] The effect of the voyage was to show that settled mission work was still impossible in the Empire, but an increased knowledge of the natives was gained, and some indications were found that the opening of China would not be long deferred.

The year 1836 was a quiet one for the missionaries of the American Board. Bridgman was busy assisting Medhurst and J. R. Morrison in a revision of Morrison's translation of the

---

[62] Williams, Mid. King., 2: 328-329. Carl Friedrich August Gützlaff, The Journal of Two Voyages along the coast of China in 1831 and 1832, etc., New York, 1833. The fact that these were published in English and in New York shows the interest with which they were followed in the United States.

[63] Corres. of A. B. C. F. M., China, 1831-7, No. 205, Stevens to Anderson, Mar. 6, 1834.

[64] W. H. Medhurst, China: Its State and Prospects with especial Reference to the Spread of the Gospel, etc., London, 1838, pp. 365-367, and Ch. Rep., 4: 308-335. This publishes part of the journal kept by Stevens during the voyage.

[65] Ch. Rep., 4: 308-335. See other accounts, not, however, with the value of this one, in Williams, Mid. King., 2: 329-330, and Foster, Christian Progress in China, p. 139.

Bible.[66] The chapel formerly occupied by the factory of the East India Company was obtained and the congregations increased somewhat.[67] Williams, whom they feared would be transferred to Singapore, still stayed on, busy with his press.[68] Language study and printing were quietly pursued, but no disturbances or new enterprises marked the year.

The year was made noteworthy, however, by the entrance of the American Baptist Board upon the Canton work. The possibilities of missions for the Chinese were becoming increasingly attractive to American churches. The Presbyterian and Dutch Reformed bodies, which had thus far acted with the American Board, were beginning to talk of independent action.[69] In April and May, 1836, the Missionary Lyceum of Wesleyan University, at Middletown, Connecticut, brought strongly to the attention of the Methodist Missionary Society the needs of China, and preliminary steps were taken to raise money for a mission there.[70] The first organization to take definite action, however, to join the American Board in its work was the Baptist Society. This had sent out its first missionary to the Chinese, Rev. William Dean, in 1834,[71] but he had settled in Bangkok. Its first missionaries to China proper, Rev. J. Lewis Shuck and his wife, Henrietta Hall Shuck, arrived there September, 1836.[72] Mr. and Mrs. Shuck were Virginians and introduced a new element into the rather conservative northern missionary body at Canton. They left Boston, September 22d, 1835,[73] stopped for a time at

---

[66] Bridgman, Life of Bridgman, p. 100.

[67] Corres. of A. B. C. F. M., China, 1831-7, No. 123, Bridgman to Anderson, Jan. 29, 1836.

[68] Ibid., No. 11, April 3, 1835, Williams and Bridgman to Anderson, and No. 13, Sept. 8, 1836, the Mission to Anderson.

[69] Ibid., Letter of Abeel to Anderson, July 23, 1835, told of the difficulties on this score.

[70] Missions and Missionary Society of the Methodist Episcopal Church, by J. M. Reid, revised and extended by J. T. Gracey. 3 v., New York, c. 1895. 1:411; 412. The project for a mission to China rested until after 1844.

[71] Dean, China Mission, p. 95.

[72] J. B. Jeter, Memoir of Mrs. Henrietta Shuck, The First American Female Missionary to China, Boston, 1846, p. 221.

[73] Ibid., p. 40.

Singapore,[74] and settled at Macao, where they began their work. Shuck baptized his first convert, Ah Loo, February 1, 1837, numerically a larger showing than Bridgman had had in the first five years of his missionary career, but the step proved hasty, as the fellow apostatized within eighteen months.[75] Life in China proved to be rather trying to Mr. and Mrs. Shuck. Relations with the other missions were not always cordial, the older workers being inclined to look upon these younger ones as unduly insistent on denominational differences, and perhaps superficial in their methods[76]; living expenses were high and salaries inadequate—$750 for the married missionary as contrasted with the $1,000 which the American Board found it necessary to pay its unmarried men. The restless Shuck attempted to get to Hainan by native boat to see if it could be opened to missionary enterprise only to be forced to return without having reached the island.[77]

As an independent worker affiliated with this Baptist mission, there arrived in 1837, Rev. Issacher J. Roberts, a man of great religious zeal, but of unbalanced optimism. He was born in Tennessee in 1802[78] and obtained an imperfect education in the Furman Theological Institution of South Carolina. He began his preaching career in 1825, and worked in the South as pastor and as agent of the American Colonization Society and of the Sunday School Union.[79] He thought for a time of going to Liberia as a missionary. A year or two later he organized the

---

[74] Baptist Missny. Mag., 17: 174, Extracts from Shuck's Journal.

[75] Jeter, Memoir of Mrs. Shuck, pp. 103, 121.

[76] In Corres. of the A. B. C. F. M., Foreign Vol., p. 37, is a letter of Anderson to the China Mission, Mar. 13, 1838, in reply to a letter of Parker, who was somewhat irritated, trying to smooth things over. In the correspondence of the American Baptist Missionary Union, Mss., in their rooms in Boston, there is a letter from Shuck, Jan. 14, 1842, telling how he had immersed an American ship-master, T. Rogers, a former Presbyterian, and of the consequent displeasure of the "pedo-baptists."

[77] Letter of Shuck to Secy. Peck, Feb. 21, 1837, in Corres. of A. B. M. U.

[78] Wylie, Memorials of Prot. Missionaries, p. 94. Hervey, The Story of Baptist Missions, p. 512.

[79] Corres. of A. B. M. U., Roberts to Bolles, July 5, 1834. Wylie says that he was ordained in 1833, but he may have been licensed before this year. Wylie, Mem. of Prot. Missionaries, p. 93.

"Roberts Fund and China Mission Society" and turned over to it his property, his hope being that it would attract additional aid as the years went by.[80] Under this society he sailed from home, in 1837,[81] and on his arrival at Macao took up his residence with Shuck. He worked in Macao for several years, preaching for a time to a colony of lepers.[82]

In addition to the arrival of Roberts the year 1837 was marked by one other incident of importance, the visit of the "Morrison" to Japan. This voyage, significant in history as one of the early attempts to open that empire, was an American undertaking from Canton, entirely pacific and largely philanthropic in its motive. Its primary purpose was to return to their homes seven shipwrecked Japanese. Three of these had been driven across the Pacific, wrecked on the Northwest Coast of America and sent by the Hudson Bay Company via London to Canton; and the other four were rescued from a wreck near Manila.[83] In July, 1837, Olyphant and Company, who had taken care of them for some time, dispatched the "Morrison" to return them to Japan. With the ship went C. W. King, Parker, Williams, and Gützlaff.[84] The party stopped at the Lew Chew Islands, where they were well received, and instead of going to Nagasaki, the only Japanese port where any foreign trade was allowed, sailed directly for Yedo Bay. Here they anchored for three days, holding some communication with the Japanese, but were fired on at the end of that time and withdrew. They went next to Kagoshima Bay, and were at first fairly well received, but later they were again fired on, and left without landing their refugees. They reached China, August 29th, their primary aim unattained. Through these same refugees, however, some acquaintance with the language of their country was obtained by Williams, who later (in 1853 and 1854) acted as

[80] Corres. of A. B. M. U., Circular letter of Roberts to the Society, Feb. 18, 1841. See also, Wylie, Memorials, etc., p. 94, Hervey, Baptist Miss., p. 512.

[81] Corres. of A. B. M. U., Roberts to Bolles, Jan. 25, 1837.

[82] Hervey, The Story of Baptist Missions, p. 513.

[83] Ch. Rep., 6: 209-229, 353-380, narrative of S. W. Williams.

[84] They took with them an assortment of articles of trade for use in case it should be found possible to open commercial relations.

interpreter to the Perry expedition, and some foreign books were translated into Japanese and printed.[85]

The year intervening between this expedition and the outbreak of the opium troubles was one of quiet growth. The Ophthalmic Hospital continued its work with increasing success.[86] Bridgman had seen the completion of the revision of the Scriptures in 1836[87] and was working on various pieces of translation and composition, among them a Chinese history of the United States, a Chrestomathy and Tonic Dictionary, and the ever-present Chinese Repository.[88] Preaching services were conducted for foreigners, distribution of books and tracts went on among the Chinese, and small schools for boys were still continuing.[89] Abeel was back for part of the time, and in 1839 Mr. and Mrs. S. R. Brown came out as reënforcements.

Closely connected with the work of the missionaries sent from the United States and Great Britain were a number of societies organized in China by the foreign residents. Under the stimulus of the compact community life and of the missionaries and a few earnestly religious merchants the decade preceding the opium troubles saw a number of these begun. Although formed and carried on partly by the British and partly by the Americans, they obtained most of their men from the United States. The first society was the "Christian Union at Canton." It was organized in the latter part of 1830 by Robert and John Morrison, Abeel, King (a nephew of Olyphant), a Moravian surgeon on an East India Company's ship, a young British midshipman, and Bridgman.[90] As the latter wrote: it "was formed to give more

[85] Four accounts of this voyage by men who shared in it are by C. W. King, in the first volume of the Claims of Japan and Malaysia upon Christendom, Exhibited in Notes of Voyages made in 1837, 2 v., New York, 1839, by S. Wells Williams in the Chinese Rep., 6:209-229, in a letter by him to Anderson in Williams, Life and Letters of S. W. Williams, pp. 94-98, and in Stevens, Life of Parker, p. 141 et sqq. Among the other accounts are brief ones in Callahan, Am. Rel. in the Pacific, p. 74, and Foster, Am. Dip. in Orient, pp. 137-140.

[86] See reports in Ch. Rep., 4:461-473 and *passim*.

[87] Williams, Mid. King., 2:363-364.

[88] Missny. Herald, 34:17, 339, 349.

[89] Ibid., 35:212-214.

[90] Corres. of the A. B. C. F. M., China, 1831-7, No. 37, Bridgman to Evarts, Jan. 27, 1831.

wisdom and strength to our efforts and better security to our friends abroad. It will not interfere with individual and private conduct; while it will give counsel and support to all, and have general supervision of the several objects of Christian benevolence which may come within its reach. It has commenced a depository and library. . . . It has or will soon open a correspondence with the several missionary stations between the capes."[91] It published "Chinese Scripture Lessons for Schools"[92] and guaranteed the expenses of the Chinese Repository for the first year.[93] After the Repository was guaranteed by Olyphant the Christian Union seems to have ended its specific usefulness, and to have lost itself in the societies formed later for more specialized activities.

A second organization was that for the "Diffusion of Useful Knowledge in China," formed in December, 1834. Its purpose was "to prepare and publish, in a cheap form, plain and easy treatises in the Chinese language on such branches of useful knowledge as are suited to the existing state and condition of the Chinese Empire."[94] In four years it had issued almanacs, and a "collection of elementary and useful information used by the young and by men of imperfect education," which included some modified Aesop's Fables, a universal history, and a history of England. A description of the United States and a history of the Jews were about to come out, and other works were in preparation.[95] It was a larger organization than the Christian Union, but as in time its work came to be done by other agencies it was allowed to lapse.

---

[91] Corres. of the A. B. C. F. M., China, 1831-7, No. 37, Bridgman to Evarts, Jan. 27, 1831. See also, Tracy, History of the Am. Bd., p. 201.

[92] Corres. of A. B. C. F. M., China, 1831-7.

[93] See Bridgman to Anderson, April 5, 1833, Corres. of A. B. C. F. M., China, 1831-7, No. 73. Tracy says that if the work had been unsuccessful, but a fourth part of the expense would have fallen on the American Board, which implies that the Christian Union guaranteed only three-fourths of the expenses (Hist. of Am. Bd., p. 224), but he does not quote his authority. I am inclined to think that Tracy may be right, and that Bridgman's statement was merely a general one.

[94] Williams, Mid. King., 2: 340.

[95] Fourth Annual Report of the Society, Nov. 21, 1838, Ch. Rep., 7: 399-410.

Next in order of age was the Morrison Education Society. Robert Morrison's life had made a deep impression upon the foreigners in Canton, and they felt that some permanent memorial should be raised to him. In January, 1835, a paper suggesting the formation of a society was circulated and by February 24th, twenty-two signatures of English and Americans and $4,860 had been obtained. A provisional committee of six was then appointed, two of whom were Americans. The organization's object was to establish and support schools in China to teach the natives the English language, western learning, and Christianity. Youths of either sex might be taken, the ages preferred being six, eight, and ten years; pupils might be sent to Malacca, India, Europe, or America for a finishing course. It was to be directed by five trustees, resident in China, but tutors and teachers were to be obtained from Europe and the United States.[96] In the first two years of the society's existence, instruction was given to five or six boys, and some aid to Mrs. Gützlaff, who had gathered a few children around her in Macao.[97] Application was early made to the British and Foreign School Society for aid and counsel,[98] and attempts were made to get teachers in England and America. In the latter country Professors Silliman, Goodrich, and Gibbs, all of Yale—whose halls had already furnished China with Parker and Stevens—were appointed a committee to secure an appointee, and after two unsuccessful attempts,[99] Rev. Samuel R. Brown, a Yale graduate of the class of 1832, was selected.[100] He reached China February 23, 1839, and at once took a few children into his home. With occasional interruptions caused by war and a trip

---

[96] Proceedings relative to the Formation of the Morrison Education Society, Ch. Rep., 5: 373. See too, Williams, Mid. King., 2: 341-345.

[97] First Annual Rep., Sept. 27, 1837. Ch. Rep., 6: 229, and second annual report, October, 1838, Ch. Rep., 7: 301-310. Yung Wing, My Life in China and America, New York, 1909.

[98] Chinese Rep., 5: 378.

[99] Second Annual Report of Morrison Educ. Soc., Oct., 1838, Ch. Rep., 7: 301-310.

[100] Third Annual Rep. of same, Sept. 29, 1841, Ch. Rep., 10: 564-587. See too, Trumbull, Old Time Student Volunteers, p. 114, and Ch. Rep., 7: 550. Griffis, A Maker of the New Orient, is a Biography of Brown.

to Singapore, the school was held continuously for a number of years.[101]

A fourth society formed by the foreign residents in China had its origin in Parker's medical work. He reached China in 1834 and opened the Ophthalmic Hospital in 1835. In October, 1836, Parker, Cooledge (an English merchant), and Bridgman, feeling that the time had come for further action, issued a pamphlet suggesting that a society be formed to aid in the medical work.[102] Nearly a year and a half later, in February, 1838, the "Medical Missionary Society in China" was formed. Its object was to "encourage gentlemen of the medical profession to come and practice gratuitously among the Chinese, by affording the usual aid of hospitals, medicine, and attendants: but . . . . the support or remuneration of such medical gentleman [was] . . . . not at present within its contemplation."[103] The Ophthalmic Hospital was at once taken over,[104] and thanks to the generosity of Howqua and the efforts of Olyphant, was put on a secure basis and in a permanent home.[105] Because of the impossibility of caring for all who would have applied, treatment was largely, although not exclusively, confined to eye diseases. Even with these limitations, the wards were crowded, and many patients had to be turned away.[106] In April, 1838, at the society's request, Parker opened a hospital at Macao. At first it met with much suspicion,[107] but this gradually disappeared and in 1839, Dr. William Lockhart, of the London Missionary Society, was appointed to devote his entire time to it.[108] Dr. William B. Diver, an

---

[101] Ch. Rep., 10: 582; 11: 337.

[102] Proposition for the Formation of a Medical Missionary Society in China, Ch. Rep., 5: 371. See too, Stevens, Life of Parker, p. 134.

[103] Formation of the Medical Missionary Society in China, Feb. 21, 1838, Ch. Rep., 7: 32-44.

[104] Ibid., and Williams, Mid. King., 2: 333-337. Lockhart, Med. Missny. in China, p. 124.

[105] Lockhart, Med. Missny. in China, p. 174. See description of the hospital in Downing, The Stranger in China, 2: 11-14.

[106] Report of Ophthalmic Hospital at Canton, Jan. 1 to June 30, 1838, showed 1,025 patients admitted during the six months. Ch. Rep., 7: 92-95.

[107] First Rep. of the Med. Missny. Soc.'s Hospital at Macao, July 5-Oct. 1, 1838, Ch. Rep., 7: 411-419.

[108] Ch. Rep., 7: 551.

American, and an Englishman, Dr. Benjamin Hobson, were accepted by the society in the same year.[109]

One more society needs to be noted, the Seaman's Friend Association in China. Like the others, it was formed by the coterie of British and American merchants and missionaries who lived at Canton. It was organized January 3, 1839, for the promotion of the welfare of all foreign seamen in Chinese waters.[110] For a time it did good work, making an examination of the conditions of the crews on board American and British ships, and holding some religious services.[111] The approach of war, however, seems to have interrupted its operations and we hear no more of it.

The second great branch of early Protestant missions to the Chinese, was, as we have noted, that outside the Empire. Three purposes actuated missionary work there. The large numbers of Chinese were an extensive field in themselves. Then there was the hope that some might be reached who would carry back to China the Christian message. And there was the opportunity for the study of the language and the establishment of presses and schools until the time when the Empire should be opened.

In the main, three large groups of Chinese colonists were easily accessible to missionaries. There was one in Java, centering at Batavia, where for the time being the Dutch government was tolerant. In the Straits Settlements, Malacca and Singapore, there was another, also under European control. At Bangkok there was still a third, under native rule it is true, but open to foreign commerce and residence. There were other groups in Borneo, in the Philippines, and in Indo-China, but they were all for one reason or another either almost or entirely inaccessible.

At the beginning of American missionary effort, these facts were not clearly recognized. The conditions of the Far Eastern Islands and Southern Asia from a missionary standpoint were not fully known, and it was felt advisable to send some one to

---

[109] Ch. Rep., 10: 448-453. William Lockhart, The Medical Missionary in China, A Narrative of Twenty Years' Experience, London, 1861, p. 127.

[110] Ch. Rep., 7: 477-484.

[111] Quarterly Report of Seaman's Friend Assn. in China, July, 1839, Ch. Rep., 8: 120-121.

gather first-hand knowledge of the situation. This was the work that Abeel took up for the American Board after his term of service at Canton as seaman's chaplain. He left China late in 1830 and visited Batavia, Singapore, and Bangkok. In January, 1832, he returned to Singapore, and then made a second visit to Bangkok, distributing books and tracts among the Chinese junks. He returned to Singapore in November, 1832, and took the place of Burn, the English chaplain, only to be compelled by failing health to go to America.[112]

A few years later another voyage was undertaken, this time by Talbot, Olyphant and Company, and on a larger scale. In 1836 they had purchased the brig "Himaleh" for the purpose of aiding missionaries in distributing books along the China coast, but no one familiar with that work could be obtained, and the vessel was sent instead to the Malay Archipelago, Stevens and an agent of the British and Foreign Bible Society, G. Tradescant Lay, accompanying her. The venture was not very successful, as Stevens died on the trip and the burden of the work was thrown on Captain Frazer, a man poorly fitted to assume it.[113]

Before this last voyage had begun, permanent American missions had been located at all three of the great centers of emigrant population. The earliest Protestant missionary effort for the Chinese of Singapore was in 1819, when an Englishman, Mr. Milton, founded the work.[114] The first American missionary stationed there was Rev. Ira Tracy. He left New York in June, 1833, with S. W. Williams, landing with him at Canton. In July, 1834, he removed to Singapore and worked there until his death, 1841.[115] Dr. Peter Parker, soon after his arrival in the East, spent several months in the same city in learning the language. Incidentally he conducted a dispensary there, and when in August, 1835, he returned to Canton, he left this and

---

[112] Abeel, Journal, p. 318. Dean, China Mission, pp. 176-192; G. R. Williamson, Memoir of David Abeel, D.D., Late Missionary to China. New York, 1848, pp. 100-119.

[113] Notices . . . . of the Indian Arch., G. T. Lay, Ch. Rep., 6:305 et sqq. Williams, Mid. King., 2:330-331. G. T. Lay, the second volume of "The Claims of Japan and Malaysia on Christendom."

[114] Medhurst, China, p. 327.

[115] Wylie, Memorials of Prot. Missionaries, p. 79.

two schools to Tracy. In the following October the latter baptized the first Chinese convert made by the American Board.[116]

Missionary supporters in America were at this time very strongly in favor of the distribution of Christian literature, and this sentiment was to be the controlling one in Chinese missions for the next few years.[117] The missionaries fell in with the plan: a press was started by Tracy at Singapore, and Parker wrote home for money, equipment, and men.[118] The American Board responded to the demand, and in May and June, 1833, wrote to Bridgman urging the early foundation of a printing establishment somewhere in the south-east of Asia.[119] In March, 1836, Bridgman was able to announce that a full printing establishment at Singapore had been purchased, consisted of two presses, of fonts of English, Arabic, Bugis, and Siamese type, and of other necessary equipment.[120] From this press various works were issued in Chinese, as well as in these other languages.

Additions came to the Singapore mission. In December, 1836, Matthew B. Hope, Rev. Joseph H. Travelli, and Stephen Tracy arrived[121]; in 1837 Rev. J. T. Dickinson[122]; and in 1838 Dr. Dyer Ball and Rev. George W. Wood, all of the American Board.[123] William J. Pohlman of the same society, who was first stationed in Borneo, came later.[124] In 1838 the Presbyterian Board sent out two men.[125] By 1840 Singapore was the most important Protestant mission station among the Chinese.

The second great accessible group of colonists from the Middle Kingdom, that in Siam, centered at Bangkok, a city whose population was half or two-thirds Chinese.[126] In 1829 or 1830 Tomlin

[116] Tracy, Hist. of Am. Bd., p. 258.

[117] Missny. Herald, 36: 208.

[118] Corres. of A. B. C. F. M., China, 1831-7, No. 190. Parker to Anderson, Feb. 19, 1835.

[119] Corres. of A. B. C. F. M., China, 1831-7.

[120] Ibid., No. 8, Bridgman to Board, Mar. 1, 1836.

[121] Tracy, Hist. of the Am. Bd., pp. 270 et sqq.

[122] Ch. Rep., 16: 12-13.

[123] Ibid., and Dean, The China Mission, p. 196, Wylie, Mem. of Prot. Missions, p. 107.

[124] Dean, The China Mission, p. 357.

[125] Ch. Rep., 16: 12-13.

[126] Malcolm estimated the Chinese population at 60,000 and that of the city at 100,000. William Gammell, A History of American Baptist

and Gützlaff, neither of them Americans, visited Bangkok and called attention to its strategic position.[127] In the summer of 1831 Abeel and Tomlin spent several months there,[128] and Abeel was there again in 1832.[129] The first resident missionary was an American Baptist from Burmah, Rev. John Taylor Jones, who set out for Siam in 1831[130] but was delayed at Singapore and did not reach Bangkok until March, 1833.[131] He began work promptly and in the same year baptized four Chinese and opened a school for boys.[132] In June, 1833, Rev. Stephen Johnson and Rev. Robinson left the United States under the American Board and reached Bangkok in 1834 after stopping for a time at Batavia and Singapore. The former spent his time among the Chinese, the latter among the Siamese.[133] Rev. William Dean and his wife sailed from America in July, 1834, under the Baptist Board.[134] Dean was detained for a time at Singapore, where his wife died, and where he himself had a narrow escape from death at the hands of some Malay pirates.[135] He reached Bangkok about the middle of 1835. Near this same time, Dr. Bradley of the American Board arrived in the city and began medical practice among the Chinese and Siamese, principally the latter.[136] The work of the American Board continued with Johnson in

---

Missions in Asia, Europe, and North America. Boston, 1849, p. 188. Ruschenberger estimated the Chinese population at 400,000; Voyage Round the World, pp. 310-314.

[127] Missny. Herald, 26: 216.

[128] J. Tomlin, Missionary Journals and Letters Written during Eleven Years Residence and Travel Amongst the Chinese, Siamese, Javanese, Khassis, and other Eastern Nations. London, 1844, pp. 306 et sqq.

[129] Williamson, Memoir of D. Abeel, p. 104-114.

[130] H. Clay Trumbull, Old Time Student Volunteers, My Memories of Missionaries, New York, 1902, p. 85.

[131] Gammell, Hist. of Am. Bap. Missions, p. 187.

[132] Ibid. The month that he arrived, a treaty was signed between Siam and the United States which gave greater security to American residents in the country.

[133] Wylie, Memorials of Prot. Missionaries, p. 80.

[134] Dean, China Mission, p. 233. Gammell, Hist. of Am. Bap. Missions, p. 190, says September, 1834, but Dean is, of course, to be preferred.

[135] Dean, China Mission, pp. 233, 97.

[136] He was molested somewhat by the government. Tracy, Hist. of Am. Bd., p. 257.

charge of the Chinese side of it, and with the assistance of Benham and Peet, who were sent out in 1839.[137] Emphasis was laid upon preaching, distribution of tracts, and education, with some assistance in medicine given by Bradley.[138] The Baptist Mission, in addition to Dean, had Rev. Alanson Reed, who reached the city in July, 1836, only to die of dysentery August 29th, 1837[139]; and Rev. Josiah Goddard, who arrived in October, 1840.[140] In December, 1835, Dean baptized three converts and organized a church, probably the first Protestant church for Chinese.[141] In July, 1838, three members were added by baptism,[142] and in October, 1839, another group of three.[143] Some of the early converts fell away,[144] but these last seem to have remained steadfast, and by 1841 the church had increased its Chinese membership to thirteen.[145] A dispensary was opened, of course,[146] and that other useful accompaniment of a mission station, a school.[147] It was the day of small things; in 1839 the school numbered only thirteen, and Sunday congregations averaged from but twenty to fifty.[148] Those in charge were hopeful, however, and regarded their work merely as preparatory to a larger labor in China when that empire should be opened.

The third accessible group of Chinese colonists, that centering around Batavia, had long been under the control of the Dutch and was in 1816 returned to their charge after the retrocession of Java by England, but what missionary work the Dutch had done seems to have had no influence upon American efforts. As elsewhere, the English were the pioneers. In 1817 Medhurst

---

[137] Benham was drowned soon after his arrival. Dean, China Mission, p. 94.

[138] Annual Rep. of the A. B. C. F. M., 1839, Missny. Herald, 35: 10.

[139] Dean, China Mission, p. 359.

[140] Ibid., p. 279, and Gammell, Hist. of Am. Bap. Missions, p. 193.

[141] Dean, China Missions, p. 115.

[142] Annual Rep. of Bap. Missny. Soc., June, 1839. The Baptist Missionary Magazine, Boston, 1821 et sqq., 19: 143-4.

[143] Ibid., June, 1840, Bap. Missny. Mag., 20: 143.

[144] Journal of Dean, Bap. Missny. Mag., 18: 30.

[145] Ibid. for June, 1841, Bap. Missny. Mag., 21: 189.

[146] Dean's Journal, May 25, 1835, Bap. Missny. Mag., 16: 45.

[147] Annual Rep. of Bap. General Convention, April, 1839. Bap. Missny. Mag., 19: 143.

[148] Bapt. Missny. Mag., 19: 143; 16: 193.

and Slater of the London Missionary Society began work. The former was there for many years, and his work and example greatly stimulated American interest. Abeel visited Batavia in 1831 while making his survey for the American Board.[149] He was welcomed by Medhurst, but his advances to the Dutch churches on behalf of the American Dutch Reformed Congregations did not meet with hearty response.[150] The first resident American missionaries were sent out in 1833 by the American Board. Here, as in Bangkok, there were two races to be reached, and of this first band of workers one, Rev. Samuel Munson, was directed to specialize on the Chinese, while the other, Rev. Henry Lyman, was to give his time to the Malays.[151] They sailed June 10, 1833, with Johnson and Robinson, the men who were to open the mission of the American Board at Bangkok.[152] They were instructed to make a short stay in Batavia, and were then to explore the neighboring archipelago for places open to Christian teachers.[153] Their work lasted but a brief time, for while exploring in Sumatra they were both killed by the hostile Battaks.[154] Undiscouraged by the loss, the American Board sent out two additional men, Rev. Elihu Doty, a minister of the Dutch Reformed Church, and Rev. Elbert Nevius, in 1836, and Rev. William J. Pohlman in 1837.[155] About 1838 the Dutch government, heretofore indifferent, began a more exclusive policy, forbidding missionary residence anywhere in its possessions except in Borneo.[156] The mission was forced to move there, but did not prosper in its new home, and when at last China was opened, Doty and Pohlman were glad to go to Amoy.[157]

---

[149] Williamson, Memoir of Abeel, p. 84.

[150] Francis Warriner, Cruise of the United States Frigate Potomoc Round the World during the Years 1831-1834. New York, 1835, pp. 145-147.

[151] Missny. Herald, 31:17, Jan., 1835.

[152] Wylie, Memorial of Prot. Missionaries, p. 80.

[153] William Thompson, Memoirs of the Rev. Samuel Munson and the Rev. Henry Lyman, etc., New York, 1839.

[154] Ibid.

[155] Wylie, Memorial, pp. 97, 99.

[156] Annual Reports of the A. B. C. F. M., Jan. 1839, and Jan. 1840, in Missny. Herald, 35:11 and 36:11.

[157] Ch. Rep., 16:12-13. In addition, there were in this Borneo Mission Jacob Ennis, William Youngblood, Frederick B. Thompson, and Miss

Another American missionary society, "The Domestic and Foreign Missionary Society of the Protestant Episcopal Church in the United States," established a station in Batavia. In May, 1834, it determined to begin work in China as soon as the proper man presented himself. In July, Rev. Henry Lockwood was appointed, and in March, 1835, Rev. Francis R. Hanson. The two sailed in a few months and arrived at Canton October 29th, 1835. Here they found the field of labor so limited that they soon removed to Singapore to learn the language, and after a few months spent there, they went to Batavia.[158] Here they planned to learn the language, to prepare and distribute tracts, and to establish schools and a dispensary,[159] the usual missionary program of the time. Both, however, had but a short term of service. Hanson retired in 1837 because of poor health,[160] and Lockwood in 1838 for the same reason.[161] The mission thus imperilled was saved by Rev. William Jones Boone, M.D., afterward Bishop Boone. He arrived at Batavia in October, 1837, and worked there until 1840, seemingly escaping the restrictions of the Dutch government. In the latter year, however, when affairs in the Chinese Empire were approaching a crisis, he brought his work in Java to an end and went to Macao.[162]

A. C. Condit, but they do not seem to have been especially for the Chinese. Annual Report of the A. B. C. F. M., Jan., 1839, Missny. Herald, 35: 11.

[158] William Cutter, Missionary Efforts of the Protestant Episcopal Church in the United States. In History of American Missions to the Heathen, Worcester, 1840, p. 590. Letter of Lockwood, Oct., 1836, in Spirit of Missions, 4: 267 (Aug., 1839). Letter of Boone, Nov. 15, 1837, Spirit of Missions, 3: 210.

[159] Letter of Lockwood and Hanson, Oct., 1836, The Spirit of Missions, New York, 1837, 2: 219, July, 1837.

[160] Spirit of Missions, 3: 66. Wylie, Mem. of Prot. Miss., p. 88.

[161] Spirit of Missions, 4: 596, letter of Boone, Apr. 3, 1839.

[162] Spirit of Missions, 7: 310.

CHAPTER V.

The Period of the Opium Troubles and of the First British-Chinese War, Culminating in the Treaties of Nanking and Whanghia, 1839-1844.

The last important set of incidents in the history of American intercourse with China before 1845 cluster around the first British-Chinese war. With the close of the East India Company's régime in Canton and the appointment of Lord Napier as superintendent of British trade, a series of conflicts began with the Chinese authorities which finally culminated in hostilities and in the treaties of 1842 and 1844. Although the struggle was between the British and Chinese alone, the interests of all Christian peoples were deeply involved, and the events of the next few years must be recited in some detail wherever American rights were at stake.

The beginning of the trouble dates back a few years before 1839. Lord Napier reached Macao July 15, 1834, to fill the office which at the close of the monopoly of the East India Company had been created for the supervision of British trade. Almost immediately after his arrival he became involved in misunderstandings with the Chinese officials, and as a result the governor suspended the English trade, September 2, 1834.[1] This practically stopped American commerce as well[2]; American merchants were detained at Whampoa[3] and business was at a standstill. Lord Napier soon withdrew from Canton, however, and the restrictions were removed.

The four succeeding years were ones of comparative quiet, but it was felt that a crisis was approaching, and that the Son of Heaven could no longer be permitted to hold himself aloof from Western intercourse. He must be brought to treat with fairness the stranger within his gates, and to hold direct intercourse with him. The inevitable conflict was precipitated by the opium question. The importation of this drug had been illegal since 1796,[4] but for fifty years it had been smuggled into the empire

---

[1] Williams, Hist. of China, p. 121.

[2] Davis, China, 1 : 119.

[3] Canton Register, September 23, 1834.

[4] Foster, Am. Dip. in Orient, pp. 64-73. The real effectiveness of the

in ever increasing quantities.[5] A large receiving station for it had grown up at Lintin, near Canton. It was smuggled in at various places along the coast, and a large traffic in it centered at Canton with the more or less open connivance of the Chinese officials. Most of the drug came from India, and through British channels, but there were few American firms at Canton who had not traded in it from time to time, and some had imported it extensively.[6] As early as 1821 the American consul was served by the hong merchants with a request that all trade in opium cease,[7] and the Terranova affair had been complicated by the fact that the "Emily" carried the drug. In the season of 1824-5, opium to the value of $133,000 was imported in American ships,[8] and in that of 1836-7, $275,921.[9] Neither of these sums is large, however, compared with the total of American imports for these years—$6,567,969, and $3,678,696, respectively.[10] It is of interest, moreover, that in Canton itself the chief foreign opponents of the traffic, aside from the missionaries, were to be found in the American firm of Olyphant and Company. They drew down on themselves a storm of criticism by taking a stand against it.[11] About 1836 the rapid growth of the trade began to con-

---

prohibition dates from a second edict in 1800. Morse, Trade and Admin. of Chinese Empire, p. 329.

[5] The amounts were: 4,000 chests, 1790; 17,000 chests, 1830; 35,000 chests, 1838. Foster, Am. Dip. in Orient, pp. 64-75. See too, Murray, Histl. and Descriptive Acct. of China, 3: 90.

[6] In 1830, one cargo, probably belonging to Thos. H. Perkins and Co., mostly opium, amounted to 160,000 pounds sterling. Testimony of Joshua Bates, Parl. Papers, 1830, 6: 365.

[7] Hong Merchants to Wilcocks, Nov. 12, 1821. Consular Letters, Canton, I.

[8] Sen. Doc. 31, 1 Sess., 19 Cong. "C."

[9] Chin. Rep., 6: 284-6.

[10] For the most part, the Americans imported the inferior Turkey opium. In 1836-7, they imported of Benares opium, 5 chests, valued at $3,415, and of Turkey opium, 446 peculs, valued at $272,506. Ch. Rep., 6: 284-286.

[11] They published a letter in the Canton Register, Aug. 21, 1838, against the traffic, and were severely scored editorially in the same paper as a result. Aug. 28, 1838. Four years later Commodore Kearney warned opium ships against using the American flag. Sen. Doc. 139, 1 Sess., 29 Cong., p. 14.

cern deeply the imperial government, both because of the drain of specie it was causing and of the disastrous effect of the drug habit upon the Chinese people. Attempts to enforce the law became more frequent and finally resulted in determined action. Early in December, 1836, some opium was seized while being landed and trade was suspended. The coolies who were handling the drug declared that it came from the American ship "Thomas Perkins," Talbot, consignee, and that they had been sent by Innes, a British merchant. The governor-general ordered the co-hong to expel Talbot and Innes. Talbot replied that the vessel had brought nothing but rice, and when Innes confirmed this statement, the case against the former was dropped, and the latter left the city. In the meantime the authorities determined to make an example of a convicted native opium dealer. They first attempted to execute him at the foot of the American flagstaff, but the foreigners forcibly interfered, and the punishment was carried out in another street. As a result of the incident, the American consul struck his flag,[12] and wrote to the Secretary of State: "I have on deliberation, resolved not to set . . . . [it] . . . . again until the receipt of orders from you to that effect, or circumstances should make it proper to do so."[13]

More important events were to follow. Late in 1838 the emperor appointed Lin Tse-sü special commissioner with the task of stamping out the entire opium traffic. Lin reached Canton March 10, 1839, and at once took drastic measures to carry out his instructions. His plan was nothing less than to destroy all the opium then in stock, and to induce the foreigners to give bonds to cease to import it. To compel the delivery of the opium, Lin caused all the foreign trade to be stopped (March 19), and the foreign merchants in Canton to be held in their factories as hostages, to be deprived of all servants, and to be shut off from all communication with their shipping and the outside world.[14] The imprisonment lasted from March 24th to

[12] Ch. Repos., 7: 437-456 gives a full account of this trouble.

[13] Consular Letters, Canton, II.

[14] W. C. Hunter, Journal of Occurrences during Cessation of Trade at Canton. Ms. in the Boston Athenaeum. Gideon Nye, Peking the Goal, Canton, 1873, p. 14. Letter of S. W. Williams, Apr. 3, 1839, Life and Letters of S. W. Williams, p. 114.

May 5th, 1839, when the opium had been given up. Of the surrendered drug 1,540 chests belonged to Americans,[15] but the American consul declared them to be merely held in charge for British subjects, and they were surrendered to Captain Elliot, the British superintendent of trade.[16]

While the foreigners were still confined to their hongs, Commissioner Lin attempted (April 5th) to get them to give bond to introduce no more of the drug. The co-hong tried to induce the American consul, Mr. Wetmore, and Mr. King, to sign such a paper on behalf of the United States. But the penalties were heavy—death for all on board a ship bringing the drug, and personal responsibility of the guarantors for all smuggling, the evidence of two coolies being sufficient to condemn—and the request was very naturally refused. Snow objected that it would call down on him the "severest censure and punishment from his superiors,"[17] but gladly agreed to the request that he solicit his government to allow no more opium ships to come.[18] The controversy dragged on for several months. Finally on July third a number of American merchants and shipmasters signed the bond in a milder form.[19]

The English refused to give the bond, and on May 21st, Elliot warned all British subjects to leave Canton. They did so, going to Macao, and when the Chinese troubled them there, to Hongkong. The Americans now carried on not only their own, but

---

[15] Foster, Am. Dip. in Orient, pp. 64-73.

[16] Consular Letters, Canton, II, Mar. 28, 1839, Snow to Lin.

[17] Snow to Secy. of State, Apr. 19, 1839. Consular Letters, Canton, II. On April 27th, Commodore Read anchored off Macao with the United States frigate "Columbia," and May 21st, the "John Adams," the other member of the East India squadron, arrived. (J. Sidney Henshaw, Around the World, New York, 1840, 2: 192, says the "Columbia" arrived Apr. 28, but William Meacham Murrell, Cruise of the Frigate Columbia around the World, etc., Boston, 1840, says April 27. This latter date is probably correct.) Their presence gave the Americans confidence (Snow to Sec. of State, May 13, 1839, Consular Letters, Canton, III), and they remained on the coast until August sixth, in spite of a protest from the Hoppo. (Murrell, p. 148. Henshaw, p. 294.) See also Paullin, Diplom. Negot. of Am. Nav. Officers, p. 188.

[18] Snow to Sec. of State, Apr. 19, 1839, Consular Letters, Canton, II.

[19] John Slade, Narrative of the Late Proceedings and Events in China. China, 1839, p. 124.

the British trade, transhipping British goods from the anchorage at Hongkong and Tongku Bay in the Canton estuary. Exorbitant freights were often charged, and some ill will was naturally felt by the English, who had either to pay the sum asked or to abstain entirely from trade.[20]

The succeeding months were precarious ones for commerce. September 11th the British declared a blockade, but withdrew it after five days.[21] A little later the Chinese became alarmed at the growing transhipments from the British "country ships" from India, the chief source of the drug, and October 14th an edict was issued threatening confiscation for all such acts.[22] October 26th another edict commanded the Americans to give a second bond to bring no opium,[23] an act precipitated by an American purchase of some of the vessels formerly used as receiving ships for the drug. The consul protested vigorously against the edict since it ordered him to examine each American ship as it entered, and to certify that its products were not English. He suggested that in its place a bond be given by each captain that he had none of the forbidden drug on board.[24] Such a bond was given in December of that year.[25]

In the meantime hostilities were pending between Great Britain and China. The British commanders threatened a blockade. They ordered one in January, 1840, but it was not effective, owing perhaps to the protests of the American consul[26] and to the ineffective British force. Although official notification of the blockade was not given by Great Britain to the United States until November 19th,[27] commerce had become so dangerous by June that the American merchants had left Canton.[28] Snow himself left in August, putting Warren Delano, Jr., in charge of his office.[29] During actual hostilities American

[20] Slade, Narrative of Late Proceedings and Events in China, p. 117.
[21] Niles Register, 57: 418.
[22] Consular Letters, Canton, III.
[23] Ch. Rep., 8: 433.
[24] Comm'r and viceroy, order, Dec. 29, 1839, Consular Letters, Canton, II.
[25] Ch. Rep., 8: 453, 462, 463. Jan., 1840.
[26] Snow to Smith, Jan. 13, 1840, Cons. Letters, Canton, III.
[27] Lord Palmerston to Stevenson, Nov. 19, 1840. Ms. in State Dep.
[28] Snow to Sec. of State, June 10, 1840, Cons. Letters, Canton, III.
[29] Ch. Rep., 9: 328.

trade was for the most part stagnant. Some was still carried on, for the British agreed to make reprisals on none but Chinese vessels, unless caught in attempting to run the blockade,[30] but many of the merchants had left China, and by the fall of 1840 imports of Chinese goods to the United States had fallen off over one half.[31]

When the Chinese authorities took stringent measures to abolish the opium traffic, missionaries as well as merchants suffered. They were detained in the factories along with the others; their Chinese teachers left them, the distribution of books ceased,[32] and Parker's hospital was closed.[33] To add to their troubles, the American financial stringency of 1837 and 1839 seemed for a time to make retrenchments necessary.[34] But the work did not entirely cease. As Americans the missionaries were looked upon favorably by the Chinese, and were allowed to remain in Canton and Macao after the English had been compelled to leave.[35] Lin, the Chinese commissioner, was favorable to the medical work,[36] and patients continued to come to Parker unmolested by the government. An assistant to Parker, Dr. William B. Diver was sent out in May, 1839,[37] and arrived September 23, 1839. Williams continued his studies in Chinese and Japanese, and his printing, and Bridgman with his assistance

---

[30] Lord Palmerston to Stevenson, June 25, 1840. Ex. Doc., 34, 2 Sess., 26 Cong.

[31] Exports from the U. S. to China. Imports from China to the U. S. for the year ending Sept. 30.

1839	$1,533,601	$3,678,509
1840	1,009,966	6,640,829
1841	1,200,816	3,095,388
1842	1,444,397	4,934,645
1843	2,418,858	4,385,566

J. Smith Homans, An Historical and Statistical Account of the Foreign Commerce of the United States, New York, 1857, p. 181.

[32] Missny. Herald, 35:463, letter from Williams, May 17, 1839.

[33] Ibid., 36:81, letter from China Mission, July 14, 1839.

[34] Corres. of A. B. C. F. M., Foreign, 2:263, Anderson to the China Mission, Nov. 16, 1839.

[35] Missny. Herald, 36:107, letter of Parker, Sept. 6, 1839.

[36] Missny. Herald, 36:74, letter of Parker, July 24, 1839, and 36:81, letter of mission, July 14, 1839.

[37] Ibid., 35:365. Corres. of A. B. C. F. M., Foreign, Vol. 2, p. 43, Anderson to China Mission, Feb. 15, 1839, and p. 92, same to same.

completed the Chrestomathy.[38] Mrs. Shuck opened a charity school in Macao which proved very popular[39] and which even attracted the favorable comment of a critical observer.[40] When actual hostilities began, however, work in Canton stopped.

During the two years of war American commerce and missions were so interrupted as to be of little relative importance. In only two incidents, the attack on the boat of the "Morrison" and the visit of Commodore Kearney, is attention drawn to the Americans. The first of these took place May 22d, 1841. The English had retaken the factories in March, a truce had been agreed upon, and trade had been reopened. But soon afterward the arrival of a new governor and the "rebel-quelling general" Yih Shan[41] seemed to presage trouble, and on May 21st Captain Elliot, the British superintendent, advised the foreigners to leave the city. Practically all did so at once, but a small party of American merchants, among them Mr. Cooledge, relying on an edict of the acting prefect of Canton which assured all neutral foreign merchants of safety, stayed over night.[42] The next morning, in attempting to get away, Cooledge was captured and taken before the magistrate. He found there the crew of a boat of the ship "Morrison," which, although it had had a *chop* or pass, had been fired on by the Chinese. One of the party, the boy Sherry, had been killed, some of the others had been wounded, and all were made prisoners. The entire party was kept in confinement for about two days, when the hong merchants released them and took them to the factories, where they left them to be rescued by the English.[43] In the spring of 1842, Commodore Kearney, of the U. S. East India squadron, arrived in China, and at once brought the matter to the attention of the native officials. He refused to treat through the hong merchants, as former American officers had been compelled to do, but sent his demands for indemnity directly to the provincial government. Quite a correspondence followed, in which the governor explained

[38] Ibid., and Missny. Herald, 36: 81, letter from mission, July 14, 1839.

[39] Corres. of A. B. M. U., letter of Mrs. Shuck to J. Peck, Mar. 14, 1839.

[40] Henshaw, Around the World, 2: 231.

[41] Williams, Hist. of China, p. 169.

[42] Ch. Rep., 10: 293-295, May, 1841.

[43] Letter of Cooledge and Account of Morss, Ch. Rep., 10: 416-420, July, 1841.

that the boat's crew had not hoisted the American flag, that it had been released as soon as the error was discovered,[44] that no mention had been made at the time of the death of Sherry, and that it had been impossible to give protection while hostilities were in progress. Kearney admitted the difficulty of finding the offenders at that late hour and waived his claims for punishment, but he demanded $7,800 for damages. This sum was promptly paid by the hong merchants, who offered to give Miller an additional $2,200 if he would acknowledge full satisfaction for his injuries. Olyphant and Company, who were the chief sufferers, were not entirely pleased with Kearney's arrangement. They took the money, however, and Kearney used their acceptance of it to restrain them from further action. The affair, so far as the claims for damages was concerned, was closed August 19th of that year, when Miller gave a receipt in full for his injuries.

This visit of the East India squadron under Commodore Kearney was a remarkable illustration of the change which the war had brought about in the attitude of Chinese officials towards foreigners. The squadron had come to protect the interests of American citizens and to obtain redress for any injuries they had suffered.[45] To do this more effectively the frigate "Constellation" went up the river to Whampoa, the first American ship of war to invade these inner waters.[46] This intrusion, which four years before would not have been tolerated, met with only the mildest protest, and communications were opened, not through the hong merchants, as had always been the custom, but directly with the governor. Moreover, a Chinese admiral visited the "Constellation," a most unprecedented action, and inspected it carefully.[47] Several other officers later followed his example.[48] Only one incident marred the visit. A boat's crew, while making soundings preliminary to moving the frigate upstream, was

[44] The correspondence is all in Sen. Doc., 139, 29 Cong., 1 Sess.

[45] Kearney to Sec. of Navy, Apr. 1, 1842. Sen. Doc. 139, 29 Cong., 1 Sess.

[46] Chinese Rep., 11 : 329-325.

[47] Chinese Rep., 11 : 320-335.

[48] Kearney to Sec. of Navy, May 19, 1842. Sen. Doc. 139, 1 Sess., 29 Cong.

fired on by the Chinese.[49] When Consul Delano, however, asked for an explanation he was assured that no harm was meant, and that the shots had been fired only after the boat had been repeatedly warned off and when it was feared that it was there with some sinister purpose and under a borrowed flag.[50] Kearney took a strong stand on the opium question, and soon after his arrival asked the vice consul at Canton to make known to the Americans and Chinese a letter of his, announcing that the United States would not sanction "the smuggling of opium on this coast under the American flag in violation of the laws of China."[51] With this and his other relations with the Chinese officials as a favorable preliminary he attempted to obtain for the Americans the advantages given to the British by the treaty of Nanking, and to prepare the way for a treaty between his nation and China. On October 8th, 1842, he wrote to Ke [Kiying], the governor, saying that he had heard that an imperial commissioner was to arrive soon to arrange commercial matters with the English, and asking Ke to endeavor to obtain for American merchants an equal footing with those of the most favored nation. A week later Ke replied that the Americans had "been better satisfied with their trade than any other nation . . . . [and] . . . . respectively observant of the laws, and that it should not be permitted that they should come to have merely a dry stick."[52] While waiting for the imperial commissioners to arrive, Kearney went to Manila,[53] but in January, 1843, he was back again, and in March resumed the correspondence. The death of the imperial commissioner delayed matters and until a successor should arrive Kearney had to be content with treating with the governor. Ke at first seemed to think that the entire question of the relations of the United States and China could be settled by a simple agreement between the commodore and the commissioner, and when Kearney told him that it was a treaty he wished, and that the United States would have to send a

[49] Ch. Rep., 11 : 329-335.

[50] Sen. Doc. 139, 29 Cong., 1 Sess., p. 11. Niles Reg., 63 : 19 (Sept. 10, 1842) says on the authority of the Canton Register that ample apology was given to Kearney.

[51] The letter is given in Ch. Rep., 11 : 239. April, 1842.

[52] Sen. Doc. 139, 29 Cong., 1 Sess., p. 21.

[53] Ibid., p. 24.

special "high officer" to negotiate it, Ke tried to dissuade him. Had not the two nations always been at peace? What need was there then of a formal compact? As to opening the other four ports to American commerce, he could not presume to decide that but must wait until the commissioner arrived. He felt certain, however, that the new trade regulations for Canton would apply equally to all nations.[54] With this answer Kearney had to be content. He had already arranged with the governor for the payment of losses sustained by the Americans in the Canton riots of December 7th, 1842,[55] and after a parting warning to his countrymen not to ship from port to port in opium vessels,[56] and after taking away the papers of the "Ariel" for trading in the drug under the American flag,[57] he left the coast.[58]

In the meantime the war had ended. The English-Chinese treaty, which had been signed at Nanking in August, 1842, had made revolutionary changes in the intercourse between the two nations. A new era had dawned. The co-hong had been abolished, a regular tariff and port regulations had been established, and four new ports had been opened. The American treaty was not obtained until nearly two years later, but for all purposes of commerce and missions the privileges granted by that of Nanking were as open to the Americans and all other nations as to the British. It is a remarkable testimony to the efficiency of the old method of trade, however, in supplying to the full the demands of the United States for Chinese goods, that in spite of the greater freedom under the new order, American commerce with China took no sudden rise, but recovered and kept on in the natural growth it had had before the war.[59] No such revolu-

[54] Ibid., p. 35.

[55] Sen. Doc. 139, 29 Cong., 1 Sess., pp. 24-29. The correspondence lasted from January to March, 1843.

[56] Ibid., p. 37.

[57] Sen. Doc. 139, 29 Cong., 1 Sess., p. 38.

[59] See too, Niles Register, 65: 100, which contains a letter from Canton published in the Boston Advertiser, describing the last few months of Kearney's visit. See also Paullin, Diplom. Negot. of Am. Naval Officers, pp. 109-201.

[59] Exports from the U. S. to China. Exports from China to U. S. Year ending Sept. 30:

1840	$1,009,966	$6,640,829
1850	1,605,217	6,593,462

tionary effects were experienced in the amount of trade as were felt in the method of conducting it or in missionary operations and diplomatic relations.

The effects of the treaty of Nanking on missions were revolutionary. The interest aroused through the missionary world by the war had been far greater than that in the commercial world, and when the progress of events made it certain that some of the old restrictions would be withdrawn the greatest enthusiasm followed. Boone, of the Episcopal board, wrote in June, 1841: "There is but one single barrier to the establishment of . . . . missions among these millions . . . . [of] heathen and that barrier of a political nature, which may be removed in a day, and which will probably break down upon the demise of some monarch, perhaps of the present, if indeed the English do not throw open to our residence before the current year is past, cities whose inhabitants will outnumber all the inhabitants of our Atlantic cities put together."[60] Bridgman wrote three weeks later: "Full toleration [of Christianity] will come sooner or later."[61]

With the expectation of an open China came the determination to throw in reënforcements. Those who had worked among the Chinese colonists prepared to transfer their operations to the Empire. Missionaries followed hard on the heels of the British army and entered the ports almost as soon as they were captured. Boone and Abeel moved to Amoy in February, 1842.[62] In February and March of that year Shuck and Roberts established a Baptist mission on the Island of Hongkong, began to build chapels, and organized a church.[63] In 1841 Ball moved from Singapore to Macao, and in 1843 to Hongkong.[64] With the signing of the treaty between China and Great Britain, August 29, 1842, the former enthusiasm was intensified. Shuck wrote his

---

J. D. DeBow, Statistical View of the United States . . . . being a compendium of the seventh census. Washington, 1854, p. 188.

[60] Spirit of Missions, 6: 366.

[61] Missny. Herald, 38: 101, letter of Bridgman, Macao, July 1, 1841. See also letters of Parker and Bridgman in Ibid., 37: 43.

[62] Spirit of Missions, 7: 310. Williams, Mid. King., 2: 338.

[63] Baptist Missny. Mag., 23: 21. Niles Register, 65: 68, Sept. 30, 1843.

[64] Dean, The China Mission, p. 196.

board September 14, 1842[65]: "I am now permitted to convey to you the glorious intelligence that peace is declared between Great Britain and China, and this land of *heathenized infidelity* has at last been thrown open!!!" Parker, newly returned from America, wrote in November of that year of the less haughty attitude of the people, and that there was "abundant evidence that a new era" had arrived.[66]

In America also, where the events of the war had been followed with close attention, it was felt that the time had come for an advance movement. Parker spent the two years of hostilities in the United States, lecturing widely, and organizing branch associations in the principal cities to help in the medical work.[67] Other returned missionaries added inspiration; news in the secular and religious journals aroused interest; and the demands for reënforcements which came from the representatives on the field found a ready response. Roberts, who had become a regular missionary[68] of the Baptist Board, Dean, and Shuck urged their board to send three additional missionary families[69] and later increased their request to one for each of the treaty ports.[70] The American Board missionaries asked for six men for Amoy, and four or five for the other ports.[71] In response to these and other calls, Walter M. Lowrie of the Presbyterian

---

[65] Correspondence of the A. B. M. U.

[66] Missny. Herald, 39: 257.

[67] Stevens, Life of Parker, p. 188 et sqq. See too, Papers Relative to hospitals in China, Boston, 1841, which contain an appeal for Parker's work by a committee of the Boston Medical Association.

[68] When the opening of the five ports seemed imminent, Roberts wrote to his society, urging that they either incorporate and plan to send out more missionaries, or else become auxiliary to the Baptist General Convention. (Corres. of A. B. M. U., Roberts to Roberts Fund Society, Feb. 18, 1841.) The latter plan was adopted, perhaps before his letter reached his constituents, and he became a regular missionary of the Baptist Board. (Ibid., Roberts to Baptist Board, April 19, 1841.) Later, in a period which does not here concern us, he played a rather questionable part in the T'ai Ping Rebellion, his sanguine temperament leading him for a time to put too high an estimate on the religious nature of the movement.

[69] July 4, 1842, Corres. of A. B. M. U.

[70] Missny. Mag., 23: 315.

[71] July 31, 1843. Missny. Herald, 40: 32.

Board and W. H. Cummings left America in 1842[72]; in 1843 Daniel J. Macgowan of the American Board came out; and in 1844 there were nine recruits,[73] more than had come to China from all the Protestant world before 1824.[74] Boone spent part of 1843 and 1844 in the United States rousing interest in the Episcopal churches, and in 1845 returned to China as missionary bishop, with three ordained men and three unmarried women.[75]

The benevolent societies formed in Canton changed much with the altered conditions. Soon after the treaty of Nanking the Morrison Education Society moved its school to Hongkong. It prospered for a time, but in 1849 came to an end.[76] The Medical Missionary Society in China had a more successful history. Immediately on the close of the war it opened a hospital in Chusan, reopened those in Macao and Canton, and assisted work in Shanghai and Amoy. It won the hearty favor of the Chinese, especially of the officials, and one branch of it still exists.[77]

The treaty between China and the United States had but little effect on the missionary enterprise. Toleration, although not included in the text, had been practically assured by the treaty of Nanking. The American and the French treaties each secured a few more rights, but the British document is the real dividing point between the old and the new eras, between an entirely closed empire and a partially open one, between hostility and partial toleration.

During the occurrence of these events in China, the American people were developing a new interest in the Middle Kingdom. Their knowledge of it had been gradually increasing for the

---

[72] Memoirs of the Rev. Walter M. Lowrie, Missionary to China, edited by his Father. New York, 1850. Cummings went out under no society, although he bore a letter of warm recommendation from the American Board to its missionaries. Corres. of A. B. C. F. M., Foreign, Vol. 4, p. 244. Anderson to China Mission, Dec. 22, 1841.

[73] Ch. Rep., 16: 12, 13.

[74] Ibid.

[75] Spirit of Missions, 9: 334, 502; 10: 28. See too, Ibid., 8: 114, 142.

[76] Annual report of Morrison Educ. Soc. for year ending Oct. 1, 1843. Ch. Rep., 12: 617-630. Williams, Mid. King., 2: 341-345.

[77] Reports of Med. Missny. Soc. in China for 1840-1, Ch. Rep., 10: 448-453, and for 1841-2. Ch. Rep., 12: 191. Ch. Rep., 13: 369-377. McLavol-

past fifty or sixty years, but at best was still imperfect. China was a separate world, and was regarded as the embodiment of all that was remote.[78] Some few facts did sift in from time to time, and a general notion had gradually been obtained of the empire, its extent, its government, and its people. Books on it were occasionally published in the United States, as, for instance, an edition of Barrows, "Travels in China,"[79] and the work of Lay, another Englishman, on "The Chinese as They Are."[80] De Ponceau had published a dissertation on the nature and character of the Chinese system of writing,[81] and Niles Register contained from time to time items of news from the country. In addition to these printed sources of information, a few Chinese had come to the United States. In 1800 James Magee brought one over to learn the English language.[82] In 1845, Atit, a Cantonese who had resided in Boston for eight years, became a citizen of the United States.[83] In 1819 another Chinese had lived in Boston for two or three years[84] and still another had been partially educated in this country.[85] Chinese were still so few and so much of a curiosity, however, that in 1834 a girl in native costume had been imported for purposes of exhibition,[86] and things Chinese were still so little known that a museum of

---

lée, Voyage en Chine, Paris, 1853, p. 356. Lockhart, Med. Missny. in China, p. 144.

[78] Providence Gazette and Country Journal, Oct. 17, 1789, in commenting on the salaries of Congressional officers while Rhode Island was still outside the Union, said: "Till this state shall adopt their government [of the United States] as well may we cavil at the salary annexed to the office of the chief mandarin at Pekin."

[79] John Barrows, Travels in China, Philadelphia, 1803. Van Bram, Voyage de l'embasade de la Compagnie de Indies Orientales vers l'empereur de la Chine dans les années 1794 et 1795, etc., was first published in Philadelphia in 1797-98, 2 vols. The American Oriental Society was formed in 1842. Journ., 1 : 11.

[80] G. Tradescent Lay, The Chinese as They Are, Albany, N. Y., 1843.

[81] Peter S. A. DuPonceau, Dissertation on the Nature and Character of the Chinese System of Writing, in Trans. of the Histl. and Literary Com. of the Am. Phil. Soc., Philadelphia, 1838.

[82] Providence Gazette, Aug. 2, 1800.

[83] Niles Reg., 67 : 384, Feb. 15, 1845.

[84] Panoplist and Missny. Mag., 15 : 448. Oct., 1819.

[85] Abeel, Residence in China, p. 106.

[86] Niles Register, 47 : 134.

curiosities brought from the empire as a business venture attracted wide attention.[87]

During these years of gradually increasing knowledge, the opinion of China had been largely one of respect and admiration. This other world, with its ancient civilization, almost as remote from ordinary American life as the planet Mars, inspired something of awe and even of envy. In the salutatory of the first volume of the American Philosophical Society the hope had been expressed that America would in the fulness of time come to possess much likeness to China in wealth, industry, and resources, for "could we be so fortunate as to introduce the industry of the Chinese, their arts of living, and improvements in husbandry . . . . America might become in time as populous as China."[88] Jefferson had held up her non-intercourse with foreign nations as ideal,[89] and as late as 1840, admiration for the nation had been expressed in a prominent magazine: "The industry and ingenuity of the Chinese in all that relates to the conveniences of life are remarkable: the origin among them of several arts of comparatively recent date in Europe, is lost in the night of time."[90] With the Opium War, however, a sudden revulsion of feeling took place, and from being respected and admired, China's utter collapse before the British arms and her unwillingness to receive western intercourse and ideals led to a feeling of contempt. There was a failure to recognize the true import of her history and her real progress, and contrasting their old ideas of her greatness with their sudden discovery of her weakness, the impression spread through America and Europe, that China was decadent, dying, fallen greatly from her glorious past.[91]

With the so-called Opium War there began in America a new

[87] Niles Reg., 55: 391, Feb. 16, 1839, mentions it as being in Philadelphia, and Nathan Dunn, Descriptive Catalogue of the Chinese Collection at Philadelphia, Philadelphia, 1839, shows a fairly complete exhibit of the manners, dress, costumes, and life of the Chinese.

[88] Oberholtzer, Robert Morris, p. 223.

[89] Thos. Jefferson to Hogendorp, Oct. 13, 1785. Writings of Thomas Jefferson, Andrew A. Lipscomb, ed. in chief, Washington, 1904, 5: 183.

[90] Hunt's Merc. Mag., 2: 82.

[91] Letters of Cushing in Sen. Doc. 58 and 67, 28 Cong., 2 Sess., passim. These are an illustration of this feeling of contempt.

interest in the affairs of the Celestial Kingdom. The war would have attracted attention in any case, since it so deeply concerned American trade and missions, and bade fair to open the country more fully to both,[92] but the added moral question raised by the intimate relations of the opium trade to the struggle called forth much additional discussion. On the whole there was a strong feeling that an unjust attempt was being made to force a poisonous drug on an unwilling nation. John Quincy Adams was clear visioned enough to see that there was a deeper question, the right of China to deny commerce to other nations, and in November, 1841, expressed his views before the Massachusetts Historical Society.[93] The lecture aroused a storm of protest and was so unpopular that the North American Review refused to publish it. The thought of crowding the deadly opium on another nation, and even of forcing her to accept any trade she did not want, antagonized the independent American spirit. Hunt's Merchant Magazine[94] came out strongly with the statement that "we can imagine no more glaring violation of the law of nations than the successful attempt which has been made to cram down her [China's] throat by force, an article which she has deliberately refused to receive. Undoubtedly the bearing of the Chinese government was preposterous, and the aspect of Chinese institutions, to a stranger, ludicrous in the extreme; but we cannot discover in what way the conceit and ignorance of the Chinese authorities can be considered sufficient to justify the summary remedies which have been adopted." John W. Edmonds, in a lecture delivered before the Newburgh Lyceum, asked indignantly, "To what code of either natural or national law are we to be referred for a principle that would justify the permanent intrusion of a foreign agent upon our domicile, either national or individual, against our will, and in defiance to our repugnance to all intercourse?"[95] Yet in this indignation there was mixed a curiously inconsistent enthusiasm over the prospect of an open

[92] Niles Reg., Vol. 57 et sqq., passim, is an example of the way news of the war was published.

[93] The paper is given in Ch. Rep., 11:274-289.

[94] Hunt's Merchant Mag., 8:205, Mar., 1843.

[95] John W. Edmonds, Origin and Progress of the War Between England and China, New York, 1841.

China and the opportunities it would offer. While deploring the means, Americans exulted in the end.[96]

Throughout the war the government kept in close touch with the situation, alive to the opportunities it might afford to the United States. January 7, 1840, a set of resolutions passed the House requesting the President to communicate information respecting American trade and American citizens in China, especially as affected by the threatened hostilities.[97] The President sent in the required information February 25th.[98] The resolutions were taken by some as an indication that the United States intended to join Great Britain in the war, but Cushing, who had originated them, and Pickens, chairman of the House committee on foreign affairs, both disclaimed any such intention.[99] A second resolution in December of the same year secured further information about the war and the blockade of Chinese ports.[100] The minister to England, Edward Everett, kept the government supplied with such news as he could collect. He did not share the popular expectation of a sudden expansion of trade as a result of the war, but believed that as then organized it amply supplied the demand.[101] He felt sure, however, that whatever advantage accrued to England as a result of the treaty of Nanking must sooner or later be shared with the other powers.[102]

With the progress of the war there came the conviction that the United States must put its trade with China on a firmer basis, that she must have there a diplomatic representative as well as a consul, and obtain treaty recognition of her rights. It had long been felt that the consul should be given more authority and be made independent of private trade. Early in the history of the trade a petition had been sent in by some of the Canton merchants asking that a "more efficient consular establishment" be organized with a consul having a salary of three thousand

---

[96] The article in Hunt's Magazine quoted above admirably illustrates this contradiction.

[97] Cong. Globe, 1 Sess., 26 Cong., p. 172.

[98] Ex. Doc. 119, 1 Sess., 26 Cong., pp. 1-85.

[99] Cong. Globe, 1 Sess., 2d Cong., p. 275. Mar. 16, 1840.

[100] Ex. Doc. 34, 2 Sess., 26 Cong.

[101] Edward Everett to D. Webster, Nov. 29, 1842. An earlier letter on the war was that of May 6, 1842. Mss. in State Department, Washington.

[102] Ibid.

dollars a year, and an experienced physician and surgeon.[103] The weakness of the old system had been clearly shown during the Terranova affair, when the consul's powers proved so inadequate. During the troubles which followed the end of the East India Company's régime, it was felt that some action must soon be taken, especially since Grosvenor, the incumbent of the office, was absent so much of the time. An American merchant in Canton wrote the government in April, 1834, urging that a consul be on the ground with extensive powers, and that a naval force be sent to watch developments. In September he wrote again, predicting hostilities between China and Great Britain, and urging more specifically that the United States send a representative to the East to deal directly with the authorities, to insure treatment as favorable as that accorded to England.[104] In June, 1837, the Chinese Repository published an article proposing a consular establishment for Eastern Asia with a consul-general at Canton, and men under him at various Eastern trade centers, all with adequate salaries.[105]

After hostilities had begun the needs of the situation were seen to include more than a mere change in the consular establishment. It was felt by all persons acquainted with conditions that the United States must obtain for herself those underlying privileges for which the war was being waged—larger freedom of residence and of trade, greater security for the persons of foreigners, and a mutual agreement as to tariff and port regulations, all based on direct intercourse between officials of the two nations and on a treaty whose fundamental principle should be mutual equality. Pressure was brought to bear on the government from various sources, urging action to this end. Even before the war had begun, on April 23d, 1839, Gideon Nye memoralized Congress, submitting "the expediency of appointing a minister to the court of Peking, empowered to establish equitable relations, *whereby his right of residence at the seat of*

[103] Consular Letters, Canton, I. It has no date, but its early nature is shown by the letters with which it is bound, and by the fact that it is signed by Perkins and Company, I. S. Wilcocks, Philip Ammidon, John Hart, Andrew Mather, William F. Magee, etc.

[104] Consular Letters, Canton, I. April 20, 1834. Ibid., II, Sept. 23, 1834.

[105] Ch. Rep., 6: 69-82. (June, 1837.)

government would be secured as a preliminary."[106] This, said he, was the only means of obtaining a final settlement of the question. In the same year, Henshaw, who was at Canton with Commodore Read, felt that the time was opportune for a diplomatic mission and large concessions,[107] and about the same time Peter Parker, whose medical services had won him favor with the Chinese, memoralized Lin, the imperial commissioner, urging that a treaty was the only final solution of the difficulties with western powers.[108] In 1840 a number of American citizens at Canton asked Congress to act with Great Britain, France, and Holland in putting matters on a safe basis. They suggested as a proper method a direct appeal to the emperor for permission for a minister to reside at P'eking, and for a fixed tariff duty, a system of bonding warehouses with regulations for trans-shipment of goods, the liberty of trading at additional ports in China, compensation for losses in the legal trade during the recent troubles with a guarantee against their recurrence, and punishment of British and American offenders only on proved guilt and by no greater penalty than in the home country.[109] In the same year a memorial from those merchants of Boston and Salem who were interested in the trade suggested that the time for sending an envoy had not yet come, but that a naval force should be sent to China sufficient to protect American interests.[110] These various recommendations all agreed that the time was either present or near at hand when the United States would have to send out an envoy to treat directly with the imperial government and arrange for trade on a more secure and a more equitable basis.

The government was naturally slow in yielding to this agita-

[106] Nye, Peking the Goal, p. 80.

[107] Henshaw, Around the World, 2: 294.

[108] "What then is the cause of the present evil between China and the other countries? Misapprehension of each other's designs and character on the part of these nations. What is the remedy? Two words express it, 'Honorable Treaty.' Such a treaty exists between all friendly nations." Stevens, Life of Parker, p. 170.

[109] Ex. Doc. 40, 26 Cong., 1 Sess. The same is in Canton Press, June 13, 1840. (Vol. 5, No. 37.)

[110] Ex. Doc. 170, 26 Cong., 1 Sess. Presented April 9, 1840, and referred to the Committee on Foreign Affairs.

tion, and felt that war with China must if possible be avoided, especially since the past friendliness of Americans, or as the proud Chinese would have put it, their obedience, had created such a favorable impression. On the other hand, when the administration came to understand the situation, it became convinced that when England should have finished the war America must do what she could to obtain by peaceful means a just share of its results. In December, 1840, John Quincy Adams proposed resolutions in Congress asking the President to communicate information about the past and present relations of the United States and China, but the motion to adopt them was lost.[111] The following month Peter Parker came to Washington and saw President Van Buren and Secretary of State Forsyth, but administrations were just changing, and he was referred to Webster, the incoming Secretary of State, and to others of the new régime. Webster received him courteously and asked him to put his views in writing. Parker did so, urging the sending of a "minister plenipotentiary direct and without delay to the court of Taou Kwang."[112] In March, after the new administration had come in, Parker saw Adams and asked him whether he would undertake the mission if it were instituted. Hawes and Cushing of the Committee of Foreign Affairs had asked Adams the same question, but he had given an evasive answer. He records in his faithful diary that he thought the time for such an action had not yet arrived, and that considering the then existing relations between the United States and Great Britain, Parker's suggestion that the former offer her mediation was impracticable.[113] In September Parker saw the President and Webster and found that Tyler had as yet taken no action because he had been in

[111] Cong. Globe, 26 Cong., 2 Sess., p. 24, Dec. 15 and 16, 1840.

[112] Stevens, Life of Parker, pp. 184-188. He urged it on the grounds that the war had unsettled American affairs, that an American minister might act as a mediator between the Chinese and the English, that there was a strong desire in China for foreign trade, that the Chinese merely wished for a pacification by which they would not "lose face," that if not soon attended to they might close up like Japan, and that the American nation was more acceptable to the Chinese than any other.

[113] Memoirs of John Quincy Adams, Comprising Portions of His Diary from 1795-1848, edited by Charles Francis Adams. Philadelphia, 1876. 10:444-445. Mar. 15, 1841.

the Senate when an act was passed forbidding the President to do more than recommend a new mission, and because he feared the possible disgrace of having an ambassador rejected.[114] Opposition did not discourage the missionary, however, and in June, 1842, he again saw Adams and again asked him if he would accept the position of envoy if one should be appointed. Adams answered that he might consider it, but that he still believed it better to send a commissioner with full powers to act rather than an envoy.[115]

The news of the Treaty of Nanking roused the administration to decision. It felt that the time had at last come when the United States could begin negotiations in safety, and when it must do so if it were to obtain advantages equal to those of Great Britain. Consequently, December 31st, 1842, the President sent a message to Congress stating his views, and advising that a commissioner be appointed to "reside in China to exercise a watchful care over the concern of American citizens, . . . empowered to hold intercourse with the local authorities, and ready, under instructions from his government, should such instructions become necessary . . . . to address himself to the high functionaries of the Empire, and through them to the Emperor himself." The message expressed the view which Adams had held, that an ambassador should not yet be appointed, since an official would have to be accredited to the sovereign and would very probably be rejected.[116] Webster seems to have been the moving spirit in the step, as it was he who wrote the message.[117] The document was referred to the Committee on

---

[114] Stevens, Life of Parker, p. 220. He quotes Parker's Journal for September 16, 1842.

[115] Adams, Diary, 11 : 166. June 2, 1842. At this point, Parker ceased his efforts and returned to China. Just how much influence his work had on the origin and conduct of the mission cannot be stated with certainty. However, he had married a relative of Webster, and had enjoyed quite a little popularity, and it seems probable that he was an influential factor in preparing the way for future action.

[116] Ex. Doc. 35, 27 Cong., 3 Sess.

[117] The Works of Daniel Webster, Boston, 1856, 6 : 463. The message is given there with a footnote attributing it to him, and the work was compiled under his direction.

Foreign Affairs, and by them to Adams.[118] The report of the committee was read January 24th, 1843, and recommended an appropriation of forty thousand dollars with which to open up diplomatic intercourse with China. It did not specify the exact way in which the sum should be used, except that it should be accounted for by the President in the manner prescribed by the Act of July 1st, 1790.[119] The amount proposed was a large one. It had been fixed at Webster's suggestion, his opinion being that it should be large enough to provide a salary equal to that of a minister to a European country.[120] There was much opposition to the size of the appropriation.[121] It passed the House, however, February 21st, by a vote of 96 to 59 with a slight amendment suggested by Webster through Adams.[122] The bill was reported favorably in the Senate without amendment, but some of the opponents of the administration thought that they saw in it a deep laid plot to give too much power to the President. Benton especially was virulent in his opposition. To his mind it withdrew the accounting of money from the Secretary of the Treasury, appropriated it for an unnecessary mission, and gave the President a chance to appoint some of his henchmen to a pleasant trip to the Orient without the consent of the Senate. Finally on March 3d, the last day of the session, the bill passed the upper house with amendments providing that no agent should be appointed under it without the consent of the Senate, and that no one person employed under it should be given more than $9,000 exclusive of

---

[118] Niles Register, 63 : 378, Feb. 11, 1863, gives the report. The Act of July 1. 1790, is in Statutes at Large, 1 : 128.

[119] Adams, Diary, 11 : 290.

[120] Webster to J. Q. Adams, Jan. 9, 1843, C. H. Van Tyne [editor], The Letters of Daniel Webster, from documents owned principally by the New Hampshire Historical Society, New York, 1902, p. 285. Curiously Adams' diary seems to be in error here. An entry on the same day (Jan. 9), p. 290, says that he called on Webster to find the amount that the latter had wished, and that Webster told him that he thought $4,000 enough for the mission, and a consul salaried at $3,000. The error may be a typographical one, or due to forgetfulness on Adams' part.

[121] Cong. Globe, 27 Cong., 3 Sess., pp. 323-325.

[122] Adams, Diary, 11 : 305, Jan. 31, 1843. Other amendments to substitute for the mission a commercial agency and an appropriation of $10,000, and to limit the salary of the commissioner to $6,000, that of the minister to Turkey, were rejected. Cong. Globe, 27 Cong., 3 Sess., p. 325.

outfit. The House concurred in the amendments and the bill was quickly signed by the President.[123]

The mission was first offered to Edward Everett, who was then minister to Great Britain, his nomination having been hurried to the Senate the last hour of the session. Webster urged him to accept it. The newspaper report was that the Secretary of State wanted the London post for himself, as he was soon to resign from the cabinet, but he wrote to Everett mentioning the rumor and emphatically denying it, saying that in the present state of affairs he had not the slightest wish to go to England. Some have thought that the denial was only apparent, not real, and have cited as evidence Webster's pending resignation and the conversation with Adams in which he asked him to write Everett urging an acceptance.[124] Everett, however, refused the

---

[123] Thomas Hart Benton, Thirty Years' View, or a History of the American Government for Thirty Years from 1820 to 1850. 2 v., New York, 1856, 2: 510-512. Benton was very much opposed to the act, and gives the impression that it was railroaded through. While adhering, except in one instance, to the facts as to dates, his account is misleading. The one error in date is where he says that the bill was taken up in the House ten days before the close of the session. It was passed there Feb. 21. Cong. Globe, 3 Sess., 27 Cong., pp. 323-325. The law as passed is in Statutes at Large, 5: 624.

[124] Those taking the position that Webster wished the English position are James Schouler, History of the United States of America under the Constitution, Vol. 4, 1831-1841, Washington, 1889, p. 436, Lyon G. Tyler, The Letters and Times of the Tylers, 2 v., Richmond, 1885, 2: 263, who quotes Adams' Diary and the letter in Curtis, Life of Webster; and Foster, Am. Dip. in Orient, pp. 77-79, who quotes no one. George Ticknor Curtis, Life of Daniel Webster, New York, 1870, 2: 178, takes the opposite position.

The documents in the case are as follows:

Webster to Everett, Mar. 10, 1843. ". . . . You see it said in the newspapers that the object in nominating you to China is to make way for your humble servant to go to London. I will tell you the whole truth about this without reserve.

I believe the President thinks that there might be some advantage from an undertaking by me to settle remaining difficulties with England. I suppose this led him to entertain the idea, now abandoned (at least for the present) of an extra mission; but in this present state of things, I have no wish to go to England—not the slightest. To succeed you in England for the mere purpose of carrying for a year or two the general business of the mission is what I could not think of. I do not mean only

place and it was then offered to Caleb Cushing. Although not certainly proved by any document, it seems probable that this nomination was a partial reward to Cushing for his faithful service to Tyler, a service which had cost him his seat in Congress and the refusal of the Senate to confirm his appointment to a cabinet position.[125]

---

that I would not be the occasion of transferring you elsewhere for any such purpose, but I mean that, if the place were vacant, I would not accept an appointment to fill it, unless I knew that something might be done beyond the ordinary routine or duties. At present I see little or no prospect of accomplishing any great object.

Embarrassed as the administration is here, and difficult as are the questions with which it has to deal, I find my hopes of success faint. Besides, I do not know who is to fill this place (which I suppose I shall soon vacate) and therefore cannot anticipate the instructions which I might receive. The President is most anxious to signalize his administration by an adjustment of the remaining difficulties with England, and by the making of a beneficial commercial arrangement. If, for any purpose, a negotiation could be carried on here, I would give the President all the aid in my power, whether in or out of office, in carrying it forward. But, without seeing clearly how I was to get through, and arrive at a satisfactory result, I could not consent to cross the water. I wish you, therefore, to feel that, as far as I am concerned, your appointment to China had not its origin in any degree in a desire that your present place should be vacated. If it were vacant now, or should be vacated by you, there is not one chance in a thousand that I should fill it." Curtis, Life of Webster, 2: 178.

Adams, Diary, Mar. 13, 1843 (11: 337), says that he (Adams) visited Webster. ". . . . I said I had been much gratified with the appointment of Edward Everett as the Minister to China, deeming the mission of transcendent importance, and deeming him by his character and attainments peculiarly well suited for it. Mr. Webster seemed much delighted, and my remarks appeared to be quite unexpected. He immediately said he would be greatly obliged to me if I would write as much to Edward Everett himself; which I said I would do with pleasure. He asked me to send the letter to him to-morrow, when the dispatches would be made up to go by the Great Western next Thursday."

[125] Williams, Life and Letters of Williams, p. 126, footnote, thinks this was true. The a priori evidence seems very strong. Benton, with his strongly partisan viewpoint, saw in the whole plan a conspiracy. Cushing had been on the committee which reported the bill, and in the House which passed it, and although his term as a member of Congress had expired, in Benton's eyes he was morally if not legally bound by the constitution not to accept the position. Moreover, he was a man whom

Preparations for the expedition were at once made. It was determined to make as ample and impressive a showing as possible. Cushing, the head, even if chosen for political reasons, was a man of unquestioned ability, and as a relative of the John Perkins Cushing who had been engaged in the Canton trade[126] may have had a previous personal knowledge and interest in the empire. The congressional appropriation was ample and Webster promised more funds if needed.[127] A squadron composed of the frigate "Brandywine," the sloop-of-war "St. Louis," and the steam frigate "Missouri," under Commodore Parker, was commissioned to carry the party, and in addition to Cushing and to Fletcher Webster, the Secretary, a number of young men were encouraged to go at their own expense to add the dignity of numbers.[128] As was wise in a work of which the home government could know so little, Cushing was given the fullest of powers. He had two commissions, one appointing him commissioner, in which capacity he was authorized to treat with the governors of provinces and cities, or with other local authorities of China, and the other appointing him envoy extraordinary and minister plenipotentiary, which he was to use in case he reached the Emperor's court at Peking. He was given full power to sign a treaty, and in his letter of instructions he was directed to obtain the entry of American ships into the ports opened to Great Britain on the same terms as those enjoyed by that power. While assuring the Chinese of the peaceful nature of the expedi-

---

the Senate would probably have rejected, and as he was appointed after that body had adjourned, and sent off before they could meet to act on the nomination, Benton thought that the law had again been violated. The President had a right to appoint during an interim of the Senate only to a vacancy in an unexpired term. (Benton, Thirty Years' View, 2: 514.) Benton, however, was prejudiced, too much so to be fair. The administration's first choice had undoubtedly been Everett, he had been confirmed by the Senate, and his refusal to accept left the office vacant. Technically, it was an unexpired term to be filled by appointment, and if the pressing opportunity were to be seized a man had to be secured, and the mission sail before Congress could meet again.

[126] They were third cousins. Lemuel Cushing, Genealogy of the Cushing Family. Montreal, 1877, pp. 46, 37, 70, 74, 24. Rev. Caleb Cushing was the great-great-grandfather of them both.

[127] Webster to Everett, Mar. 10, 1834; Curtis, Life of Webster, 2: 178.

[128] Webster to Cushing, May 8, 1843, Sen. Doc. 138, 28 Cong., 2 Sess.

tion, he was to preserve the dignity of the United States Government, and to assert always that he was no tribute-bearer. If possible, he was to reach Peking. To that end he was given a letter from the President to the Emperor, which he was to deliver in person, or to send by a proper messenger if assurances were given of a friendly reply signed by the monarch himself. The question of kotow was left to his own judgment: "All pains should be taken to avoid the giving of offense, or the wounding of the nation's pride; but at the same time you will be careful"—so the instructions ran—"to do nothing which may seem even to the Chinese themselves, to imply any inferiority on the part of your government . . . ." And last of all, he was to insist on the principle of the most favored nation treatment.[129] Both the letter of instructions and that of the President to the Emperor were the work of Webster.[130] The former was a dignified, succinct statement, showing the best of judgment, if here and there an ignorance of China, but the latter reads much like a missive to some barbarian prince, and echoes that same feeling of superiority which later characterized Cushing's communications.[131]

The mission was looked upon rather critically by many Americans as a Tyler undertaking, and some doubt was expressed as to its success. Benton, of course, had nothing good to say of it.[132] Niles found fault with the display and pomp and preferred "such a demonstration of republican simplicity as our first of American ministers, Benjamin Franklin . . . . had the intrepidity to make at the most scrupulous court of aristocrats in Europe," in preference to the "unavailing mummery of

---

[129] Sen. Doc. 138, 28 Cong., 2 Sess. Webster to Cushing, May 8, 1843.

[130] Foster, Am. Dip. in Orient, p. 81, thinks that the letter of the President to the Emperor, because of its inferior quality, was written by Tyler or Webster's successor, Upshur, who countersigned it; but it is given in Webster's works, ed. 1856, 6:477; with a footnote attributing it to him. Webster had evidently made something of a study of the situation. He wrote to the merchants in the China trade, asking for suggestions in regard to the mission, April, 1843. Letters and Recollections of J. M. Forbes, 1:115.

[131] Sen. Doc. 138, 28 Cong., 2 Sess., Tyler to Empr. of China, July 12, 1843.

[132] Benton, Thirty Years' View, 2:515.

courtly style."[133] He later gave space to a letter from a merchant in Canton criticizing the objects of the mission.[134] The treasurer of the American Oriental Society was very sceptical as to its success in reaching Peking, and, seemingly, of the probability of a treaty.[135]

Cushing left the United States in the summer of 1843, in the "Missouri." The plan was for him to go to Egypt, thence overland across the Isthmus of Suez, and by sea to Bombay, where he was to meet the squadron. At Gibraltar, however, the "Missouri" caught fire and burned, and Cushing went on by British conveyance to Bombay. Here he was taken on board the "Brandywine" and completed his voyage to Canton.[136]

In the meantime, on September 22d, 1843, Paul S. Forbes, recently appointed United States consul at Canton, had reported his arrival to the Imperial Commissioner, and in doing so, apprised the latter of Cushing's coming. He told of the special commission from the United States and asked the best route to pursue to Peking. Kiying replied advising against the proposed trip to the capital, saying with characteristic suavity that it was too long for a party which had already come so far and that their business could just as well be conducted at Canton.[137]

Cushing arrived at Macao February 24th, 1844, and on the 27th sent a tactful letter to the acting viceroy of the provinces of Kwangtung and Kwangsi. He announced his mission, saying that he was on his way to Peking to deliver a letter to the Emperor, and had stopped for a few weeks at Macao until the "Brandywine" should have taken on provisions and prepared to continue to the mouth of the Peiho, and that he wished to take this opportunity to inquire after the health of his majesty. Ching, the acting viceroy, replied on March 19th, saying that the inquiry after the Emperor's health showed "respectful obedience and politeness exceeding to be praised," but strongly urged Cushing not to think of going to Peking, since the Emperor must first be

[133] Niles Register, 64: 308, July 15, 1843.

[134] Ibid., 67: 36, Sept. 21, 1844.

[135] Greenough, China, in Journ. of Am. Oriental Soc., 1: 143-161, Boston, 1849. (Paper presented to the Society in 1844.)

[136] Benton, Thirty Years' View, 2: 515, is very bitter against the entire expedition.

[137] Consular Letters, Canton, III.

memorialized, and since even a merchant ship had never been there. Then, too, said the viceroy, there would be no interpreter at the capital, and no commissioner with power to make a treaty. The English had not carried on their negotiations at Peking, an imperial edict had already been issued (after Forbes' warning) ordering Cushing to be stopped, and after all, a treaty was not at all necessary.[138] This began a correspondence between the two in which the American hastened the appointment of a commissioner by threatening to go to Peking. March 23d, Cushing replied to Ching's first letter, refusing to discuss the matter of a treaty with any but an imperial commissioner, and still insisting on going north, although expressing his willingness to go by land.[139] Ching replied that the latter was impossible,[140] and that a reply from Peking might be expected in about three months.[141] Some four days later Cushing again expressed his intention of going north, saying that if the court had wanted him to stay at Canton it would have forwarded the viceroy instructions for his reception, and reminding him that a refusal to receive embassies of friendly states was considered among western nations a just cause for war.[142] This, and the proposal that the "Brandywine" come up the river to Whampoa and fire a salute, brought a reply from Ching after the short interval of three days, still protesting that a treaty was unnecessary, since trade had been carried on so long and so successfully without one, and informing Cushing that the law of the land did not permit ships of war in the river, nor to fire salutes, "although it is all very peaceful and done with the best intentions."[143] Ching complained, too, that Forbes had opened a letter sent by the former through him to Cushing. Two days later he sent another letter, explaining the non-appointment of an Imperial commissioner by the ignorance of the government as to when Cushing would arrive.[144] Cushing in a reply explained that Forbes had opened

[138] Sen. Doc. 67, 28 Cong., 2 Sess., p. 2.
[139] Sen. Doc. 87, 28 Cong., 2 Sess., p. 5.
[140] Ibid., p. 7, April 1st.
[141] Ibid., p. 10, April 4th.
[142] Ibid., p. 12.
[143] Sen. Doc. 67, 28 Cong., 2 Sess., pp. 13, 16.
[144] Ibid., p. 20.

the letter by mistake,[145] and that if the acting viceroy had sent it directly to his house the accident would not have happened. He then lectured Ching on the use of salutes. "China," said he, "will find it very difficult to remain at peace with any of the great states of the West, so long as her provincial governors are prohibited either to give or to receive manifestations of that peace in the exchange of ordinary courtesies of national intercourse." On May 9th, Cushing wrote saying that he would wait a little longer before going North, to allow ample time to hear from Peking, and reminded Ching that "foreign ambassadors represent the sovereignty of their nation. Any disrespect shown to them is disrespect to their nation. . . . Causelessly to molest them is a national injury of the gravest manner." He also said that the delay would cause dissatisfaction in the United States.[146] However, the American was secretly not anxious to go to Peking. He preferred to negotiate at Canton rather than to jeopardize the success of his mission by going to Tien Tsin or Peking.[147]

Cushing's insistence on going to the capital and his growing impatience finally had its desired effect. Kiying, the newly appointed viceroy of Kwangtung and Kwangsi, was made Imperial High Commissioner and was given full powers.[148] Cushing with a parting note to the acting viceroy expressing his satisfaction at Kiying's appointment, but reasserting his intention of ultimately going north, prepared to meet the commissioner. He later felt that the months of waiting had been well spent. His correspondence with Ching had settled the question of the necessity of a treaty, and had given him the chance to "say all the harsh things which needed to be said and to speak to the Chinese government with extreme . . . . frankness in a degree which would have been inconvenient . . . . in immediate correspondence with" the commissioner.[149] Kiying made

[145] Ibid., p. 17, Apr. 22, 1844.

[146] While this discussion was going on, there was some minor disturbance over the weather vane on the new American flagstaff in Canton, which the Chinese thought brought ill-luck; but it was removed as soon as the objection was raised, and the trouble ceased. Ch. Rep., 13:227.

[147] Cushing to Upshur, May 27, 1844, and the same to Calhoun, July 15, 1844, Sen. Doc. 67, 28 Cong., 2 Sess., pp. 31, 58.

[148] Ibid., p. 28.

[149] Cushing to Sec. of State, Ibid., p. 40. (July 9, 1844.)

his public entry May 30th,[150] and negotiations were at once opened. The relations between the two commissioners were on the whole very pleasant. The first two letters from the Chinese had in the address the name of the United States one line below that of the Chinese government, an expression of inferiority, but when Cushing returned them, tactfully considering the offense the "result of clerical inadvertance," they were promptly corrected.[151] On July 17th, Kiying crossed the boundary to the Portuguese colony of Macao, and took up his residence in a temple in the village of Whanghia, or Wang Hiya. The next day he visited the fleet, and on the following day (June 19th), the Americans returned the call. That same evening three Chinese officers attending the commissioner met Webster, Bridgman, and Peter Parker, Cushing's secretaries, and arranged the course of the negotiations.[152] On the 21st, Cushing presented a *projet* for a treaty, basing it, as he said, on five principles[153]: that the United States were to treat with China on a basis of friendship and peace; that they did not desire any perfect reciprocity, but since their ports were all open to the ships of all nations and there were no export duties, and since the Chinese had opened only five ports and had an export tariff, they would acquiesce in the view of the subject which it had pleased the Emperor to adopt; that any difference between the American *projet* and the British treaty was due to the fact that Great Britain had possession of Hongkong, and the United States neither possessed nor desired such a concession; and that in drawing up the *projet* the interests of both sides had been borne in mind. The Chinese and American secretaries met for several days, sometimes in Cushing's house in Macao, sometimes at Whanghia, and discussed and modified this *projet* until both principals were satisfied. Within the first week after their meeting, Kiying told Cushing that if he insisted on going to Peking negotiations must be broken off. Cushing yielded with a show of reluctance, stipulating a

[150] Chinese Rep., 13: 335.

[151] Cushing to Sec. of State, Sen. Doc. 67, 28 Cong., 2 Sess., p. 34. (June 13, 1844.)

[152] Cushing to Sec. of State, July 8, 1844, Sen. Doc. 67, 28 Cong., 2 Sess., p. 38.

[153] Cushing to Kiying, June 21, 1844, Ibid., p. 41.

condition which the other was most willing to grant, that if ministers of western nations were thereafter received at the capital an American envoy would also be welcomed.[154] Cushing asked and obtained, however, permission to send through the Commissioner the President's letter to the Emperor.[155] Negotiations proceeded without further incident, and on July 3d the treaty was finished and signed. The next day Cushing issued a letter to the American merchants announcing the treaty and on July 5th Kiying returned to Canton.

The document so obtained was a credit to Cushing and remained the standard for settling difficulties between Chinese and foreigners until the treaties of 1860.[156] In general it provided for the things stipulated by the English treaty.[157] Americans could reside for the purposes of commerce in the five ports of Canton, Amoy, Foochow, Ningpo, and Shanghai; a definite tariff was to be promulgated and annexed to the treaty; consuls were to be allowed to reside in the open cities and communicate with Chinese officials on equal terms; the old co-hong was to be abolished; no prohibitions were to be placed on trade in these ports; and the most-favored-nation clause was inserted. The British treaty contained some clauses which the American document did not have; the cession of Hongkong, indemnity of debts due British merchants by members of the co-hong, the release of prisoners of war, and the gradual evacuation of Chinese ports. On the other hand, the American treaty was a much longer and more carefully drawn instrument, and was superior to it in a number of important points. Cushing enumerated sixteen of these in a letter to John Nelson, written on July 5th, 1844.[158] (1) The tariff was amended in favor of American articles, such as ginseng, contraband articles, and matters of government monopoly, and could be changed only by mutual agreement. (2) By the

[154] Cushing to Sec. of State, July 8, 1844, Sen. Doc. 67, 28 Cong., 2 Sess., p. 38.

[155] The official reply to this letter was sent the following December in due form, approving the treaty. Niles Reg., 68:253. June 28, 1845.

[156] Williams, Middle Kingdom, 2:267.

[157] The English treaty is in Lewis Hertslet, A Complete Collection of the Treaties and Reciprocal Regulations at Present Subsisting between Great Britain and Foreign Powers, etc., London, 1845, 6:221-225. The American Treaty is in U. S. Statutes at Large, 8:592-605.

[158] Sen. Doc. 67, 28 Cong., 2 Sess., p. 77.

English treaty, the consuls were made responsible for the payment of duties, but in the American treaty this was avoided by stipulating that these should be paid in cash. (3) A new provision was made allowing goods to be shipped from one port to another without paying double duty. (4) To secure the dignity of consuls the privilege was given to them of complaining to the superior officers of any disrespectful treatment. (5) Duties were to be paid only as the cargo was landed, and a ship remaining for forty-eight hours without breaking bulk was free from tonnage and other duties. (6) Citizens of the United States were to have accommodations in all five ports, and the privilege of renting sites for houses and places of business, hospitals, churches, and cemeteries.[159] (7) It was permitted to foreigners, contrary to the former Chinese law, to hire persons to teach them the language, and to buy any kind of book. (8) A principle of more than ordinary importance was that of exterritoriality, one of the distinct contributions of the treaty to the diplomacy of the Far East. In the letter to Calhoun, September 29th, 1844, Cushing traced the reasons which led him to introduce it.[160] He showed how to his mind, it had originated in the Italian settlements in the Levant, and had been the rule in semi-barbarous and Mohammedan states. The states of Christendom "acknowledge the authority of certain maxims and usages, received among them by common consent, and called the law of nations, . . . but which is in fact, only the international law of Christendom. . . . [They] have a common origin, a common religion, a common intellectuality," allowing free residence and travel in each other's domains to citizens of the other, "and they hold a regular and systematic intercourse as governments. . . . All these facts impart to the states of Christendom many of the qualities of one confederate republic." China, not because she was inferior in civilization, but because she was not of the family of Christendom, was neither recognized nor could be treated according to this law, and so the citizens of European powers should not be made subject to her laws. The Chinese had been partly prepared for the step by the Portuguese jurisdiction at

[159] The last three were added as a special favor to Peter Parker. Stevens, Life of Parker, p. 234.

[160] In House Ex. Doc. 69, 28 Cong., 2 Sess., and in Sen. Doc. 58, 28 Cong., 2 Sess.

Macao, and by the control of foreigners at Canton over their mutual relations, but whatever the precedents or whatever the argument by which Cushing got at it, he obtained the first formal recognition in China of the principle in the form in which it is now so important.[161] (9) The citizens of the United States were placed under the protection of the Chinese government, and the latter agreed to defend them from insult and injury. (10) Vessels of the United States could go and come freely between the ports of China, with full respect for the neutrality of their flag, provided, of course, that the latter should not protect hostile troops, or be used fraudulently on the enemy's vessels. (11) Provision was made for the relief of vessels and their crews when stranded or wrecked on the coast of China. (12) A somewhat more elaborate provision than that in the British treaty was made for communication on mutually equal terms between officers, and between officers and citizens of the United States and China. (13) No presents were to be demanded of either governor by the other. (14) Ships of war, contrary to the old usage, were to be courteously received in the ports of the Empire. (15) Provisions were made for communication between the United States and the court of China such as had been obtained by none before but Russia, it being stipulated that such should be made through certain specified Chinese officials.[162] (16) Finally, in sharp contrast to the British treaty, which did not so much as mention the opium question, the treaty of Whanghia provided that any American citizen engaging in the opium or other contraband trade, should be dealt with by the Chinese government without countenance or protection from the United States, and pledged the latter to take steps to keep her flag from being used by the subjects of other nations to cover illegal trade.

[161] This clause brought as its result the necessity for an adequate consular staff in China, a necessity which was to be met later. Sen. Doc. 58, 28 Cong., 2 Sess. Cushing to Calhoun, Oct. 1, 1844. Also in House Ex. Doc. 69, 28 Cong., 2 Sess. A precedent for exterritoriality occurred as early as 1687 when a Chinese official suggested that an English sailor who had committed depredations on Chinese property, be punished by his fellow countrymen. Eames, The English in China, London, 1909, p. 40.

[162] Sen. Doc. 67, 28 Cong., 2 Sess., p. 54, gives the further negotiations in regard to this on July 13th to 28th inclusive, in which Kiying vainly tried to get this point modified.

In addition to these points enumerated by Cushing may be mentioned the privilege of hiring servants; the careful regulation of port charges; the provision for standard weights and measures; the non-responsibility of either government for debts due by its subjects to those of the other; the careful provision against fraud; the apprehension and delivery of deserters and mutineers by the Chinese government; and the provision for the revision of the treaty after twelve years. Most of the points of the treaty covered questions which had long been sources of dispute and irritation, and show the thoroughness with which Cushing had studied the situation.

On the whole the treaty was a very creditable piece of work. As Curtis said,[163] "The selection of Caleb Cushing as the first diplomatic representative of the country was most fortunate and wise. Looking over the correspondence conducted by him with the Chinese officials in the light of after years of experience in dealing with those personages, one can not but feel impressed with the keen insight into their strange character and motives. . . . He was firm in maintaining the dignity and power of the United States."

While negotiations were still in progress an occasion arose for testing the exterritoriality clause. On June 15th some Americans fired in self-defense on a Chinese mob which was troubling the factories, and one of the assailants, Sue Anam, was killed. Ching, the acting viceroy, asked the consul to deliver the man who had fired the shot, but Forbes refused and Cushing instructed him to stand by his position, insisting that American citizens in China should be responsible only to their own government. There was a short correspondence between Kiying and Cushing, the former asking that the man be given up, and the latter refusing, reviving as a counter claim the death of Sherry. The matter was dropped for a time but late in July Kiying again took it up. Cushing still held that the shooting was in self-defense, for a committee of American residents in Canton had so decided it, and the complaint was finally dropped. The outcome of the incident was in sharp contrast to that of the Terranova affair, and was a fortunate precedent.[164]

[163] William Eleroy Curtis, The United States and Foreign Powers. Meadville, Pa., 1892, p. 256.

[164] The documents are all in Sen. Doc. 67, 28 Cong., 2 Sess., pp. 63-67, 73, 95, 96.

While in China, Cushing arranged some other matters; new regulations for the foreigners in Canton,[165] and the removal of a shipyard which some Americans had started near Hongkong contrary to the treaty.[166] He finally left in the U. S. Brig "Perry," going to San Blas, Mexico, and thence home. The treaty was approved by the Senate without opposition,[167] and ratifications were exchanged at Canton with much solemnity December 31st, 1845, by Commodore Biddle.[168]

With the signing of the Treaty of Whanghia American intercourse with China had fully entered a new era. The old life had passed away. The lordly co-hong, the factories with their peculiar rules of life, the strict supervision exercised over the "barbarians," Chinese jurisdiction over foreigners, and the restricted, almost furtive missionary work, had disappeared, and instead were treaty recognition, freedom of residence, of commerce, and of missionary work, liberty from personal responsibility to Chinese courts, and direct official intercourse on the basis of equality. It is true that the struggle between China and the West had only just begun. Ignorance and the feeling of lofty superiority were still scarcely shaken. The spirit of contempt, fear, and greed which had created the old régime still existed with nearly all its old force, and no lasting change could be effected until it should disappear. The treaty of Whanghia, however, marks a transition, the end of the preparatory period, and the beginning of recognized official relations between the United States and China.

---

[165] Ibid., p. 87.

[166] Ibid., p. 80.

[167] Message of President transmitting it to the Senate, Jan. 22, 1845, Sen. Doc. 58, 28 Cong., 2 Sess. The expenses of the mission had exceeded the appropriation by about $4,000. President's Message, Sen. Doc. 17, 29 Cong., 1 Sess.

[168] Cordier, Hist. Rel. Ch. avec Puis. Occid., p. 98. Ch. Rep., 14:590. Biddle had taken it in the stead of the special commissioner who had been appointed for that purpose. The latter's health had compelled his return before reaching China. Annual Message of Polk, Dec. 2, 1845, Richardson, Mess. and Papers of the Pres., 4:401.

BIBLIOGRAPHY.

In the bibliography given below the attempt has been made to give practically all the sources and secondary works important for the subject covered in the preceding pages. All the main libraries and accessible collections of New York, New Haven, Washington, Providence, Boston, and Salem, and to a certain extent, Philadelphia, have been carefully examined. There may remain some manuscript collections in Philadelphia and Baltimore which would be of value, and there are undoubtedly valuable private collection of papers, such as the personal papers of Elias H. Derby, which for one reason or another have been inaccessible or unknown to the author. It is not likely that any further discoveries of material will greatly alter the conclusions reached, however, except perhaps to expand the paragraphs on the history of the merchant houses of New York, Philadelphia, and Baltimore.

In enumerating the sources and authorities used the attempt has been made in most cases to indicate briefly the contents of the book or document, as far as concerns the subject in hand, and in some cases to state as well as can be done in a sentence, its value and reliability. No elaborate critical notes have been attempted, as they would have made the bibliography too bulky.

In all cases the present location of the manuscript is given, and in some cases, of the printed books. Most of the printed sources and authorities are in the Yale University Library, the Day (Missionary) Library of the Yale Divinity School, and Prof. Frederick Wells Williams' private collection. With a few exceptions it may be understood that unless the location of a book is given, it will be found in one of these places.

1. BIBLIOGRAPHIES.

There is no printed bibliography which is at all complete. The following contain very brief book lists for this period:

CORDIER, HENRI.

Bibliotheca Sinica, Dictionaire Bibliographique des Ouvrages Relatifs á l'Empire Chinois. 4 v., 2d ed., Paris, 1904-1908. Pages 2510-2519. Relations des Etrangers avec les Chinois. X.

Etats-Unis. This, although meager, is the fullest printed bibliography of the subject.

Chinese Repository.

Bibliography of Printed Books on China, mostly in English and French. Chinese Rep., 18: 402-444. This is old, contains no references to manuscript material, and covers our subject only incidentally.

Hart, Albert Bushnell.

Manual of American History, Diplomacy, and Government, for Class use. Cambridge, 1908.

Page 139 contains a brief bibliography of the negotiations leading to the treaty of Whanghia.

Stevenson, William.

Historical Sketch of the Progress of Discovery, Navigation, and Commerce from the Earliest Records to the beginning of the Nineteenth Century. Edinburgh and London, 1824.

At the end are bibliographical notices of some of the voyages of the time.

2. OFFICIAL DOCUMENTS AND REPORTS OF SOCIETIES.

Reports of the American Board of Commissioners for Foreign Missions, Boston, 1812-1845.

There are in the preceding pages no footnote references to these reports, as their summary was printed each year in the Panoplist and Missionary Herald, and it is more convenient to refer to them there.

Proceedings of the First Ten Years of the American Tract Society, Instituted in Boston, 1814. (Boston) 1824.

Annual Reports of the American Tract Society.

See those from 1833 to 1844 inclusive (published in Boston), for information about the part that this society had in missions to China.

Benton, Thomas Hart.

Abridgment of the Debates of Congress from 1789 to 1856. New York, 1857-1861.

Benton, Thomas Hart.

Thirty Years' View, or a History of the American Government for Thirty years from 1820 to 1850. 2 v., New York, 1856.

This work, in 2: 510-522, tells of the Chinese mission. It is highly colored by Benton's prejudices, which were strongly anti-Cushing.

GREAT BRITAIN.

America and England, 1783-1791. (Back Title.)

Two volumes of manuscript transcripts in the Lenox Library, with the catalogue title of "America and England." They were to furnish intelligence of the current events in America from 1783 to 1791, and were written to the British Government by P. Bond, Sir George Yonge, and others, showing the state of the country under the Confederation. The collection throws light on the beginning of American commerce with China.

GREAT BRITAIN.

Calendar of State Papers, Colonial Series, America and the West Indies, preserved in the public record office.

Oct. 27, 1697–Dec. 31, 1698, ed. by Hon. J. W. Fortescue. London, 1905.

May 15, 1696–Oct. 31, 1697, ed. by Hon. J. W. Fortescue. London, 1904.

These two volumes contain references to American pirates in eastern waters during these years.

GREAT BRITAIN.

Parliamentary Papers, 1821. Vol. 7, pp. 1-421.

Reports from Committees. Brought from the Lords' Report (Relative to the trade with the East Indies and China) from the Select Committee of the House of Lords, appointed to inquire into the means of extending and securing the Foreign Trade of the Country . . . . together with the Minutes of Evidence taken in Sessions 1820 and 1821, before the said committee, Ordered by the House of Commons to be printed, May 7, 1821.

This is of value because of the exhaustive evidence taken from persons well acquainted with the trade, and covering the American as well as the British commerce.

GREAT BRITAIN.

Parliamentary Papers, 1830. Volumes 5 and 6.

Reports of Committees, East India Company's Affairs. Session Feb. 5–July 23, 1830.

This is of value for the same reasons as the preceding. In the Library of Congress.

Great Britain.

Parliamentary Papers, 1833. Relating to India and China, and the Finances of India. Return to an order of the Honourable House of Commons dated 3 April, 1833, for Continuation to the latest period to which they can be made up, of all accounts relating to the trade of India and China, etc. In the Boston Public Library.

Great Britain.

Parliamentary Papers, 1833. East India Charter Correspondence.

Pages 13, 14, 15, give some statistics on American trade made up by Thomas S. Cabell, accountant general of the E. I. Co., probably from the Company's statistics. In the Boston Public Library.

Great Britain.

The Parliamentary Debates, forming a continuation of the work entitled "The Parliamentary History of England," published under the superintendence of T. C. Hansard.

2d Series, 1820 et sqq. 3d Series, 1830 et sqq.

These contain the debates on the East India Company's Charter and so give much information concerning the impression which American trade with China made in Great Britain.

Great Britain.

The Statutes at Large. London, 1763 et sqq.

The collection is used here for the charter of the East India Company.

Hamilton, Alexander.

Trade with India and China, Communicated to the House of Representatives, February 10, 1791. American State Papers, Finance, 1 : 107.

Hertslet, Lewis.

A complete collection of the Treaties and Reciprocal Regulations at Present Subsisting between Great Britain and Foreign Powers, etc. London, 1845.

Vol. 6, pp. 221-225, contains the Treaty of Nanking, Aug., 1842.

New York Custom House.

Sea Letter Books of the New York Custom House. In the New York Custom House.

After March 11, 1799, they gave the names of all vessels clearing for foreign ports. The dates covered by the books are June, 1798–Apr. 12, 1800; Apr. 12, 1800–Nov. 6, 1802; Oct. 1, 1804–July 29, 1809; Jan. 2, 1818–Oct. 1, 1819; 1829–1831; 1832; 1836; Apr. 1, 1844–Mar. 31, 1847.

Proceedings of the Board of Missions of the Domestic and Foreign Missionary Society of the Protestant Episcopal Church in the United States of America.

See especially those published in New York, 1836-1841.

The references to China, as a rule a summary of the year's operations there, are for 1836, p. 94; for 1838, pp. 76, 77; for 1839, pp. 83-86; for 1840, pp. 57-60; for 1841, pp. 58-59.

Providence Custom House.

Impost Books of the Providence Custom House.

Books A, B, C, 1827, and D, are in the Rhode Island Historical Society. Copies of A and B are in the Custom House. It is possible through these, which cover all the years between 1790 and 1844, to determine the names, consignees, and the duties paid by all the ships which entered this port from China during this period.

Salem Custom House.

Impost Books of the Salem Custom House. In the Salem Custom House. These give information concerning Salem's trade with China.

Salem Custom House.

Digest of the Duties of the Salem Custom House. In the Salem Custom House. Book I, 1789-1851, is a more convenient summary for our purpose than the impost books.

Annual Reports of the Seaman's Friend Society.

See especially the first sixteen of these, published annually, New York, 1829-1844. They give information about the chaplaincy for sailors at Canton.

Thwaites, Reuben Gold. [Editor.]

The Jesuit Relations and Allied Documents. Travels and Explorations of the Jesuit Missionaries in New France, 1610-1791. Cleveland, c. 1900.

This is used here for notices regarding the discovery of ginseng in Canada by the Jesuits.

United States.

American State Papers. Foreign Relations. Washington, 1858. This is of use for the correspondence with Russia over the Northwest Coast, given on 5:456.

United States.

American State Papers. Documents Legislative and Executive of the Congress of the United States.

Commerce and Navigation, 1:599; 2:63. Washington, 1832. The quotations refer to trade statistics of the Chinese commerce.

Consular Letters, Canton.

Manuscript in the Bureau of Manuscripts and Archives, State Department, Washington, D. C.

Vol. I, March, 1792, to August, 1834. Vol. II, Sept., 1834, to Apr., 1839. Vol. III, May, 1839 to 1849.

This collection of letters, chiefly reports of the consul at Canton to the State Department, is one of the most valuable manuscript sources for the entire subject of the early relations between the United States and China.

United States.

The Congressional Globe. Washington, 1833 to 1873.

This contains the debates on the mission to China.

See especially, 26 Cong., 2 Sess., p. 24; 26 Cong., 1 Sess., pp. 172, 275; 3d Sess., 27 Cong., pp. 323-325; app. p. 93; 28th Cong., 1 Sess., p. 226.

United States.

The Papers of the Continental Congress. Mss. in Manuscript Department of the Library of Congress. See the following on the beginning of American trade with Canton. Reports of Committees, Vol. 5, pp. 9, 43. List of Letters, (No. 185) from Nov. 5, 1781, p. 127.

United States.

The Debates and Proceedings in the Congress of the United States with an Appendix Containing Important State Papers and Public Documents and all the Laws of Public Nature, with a Copious Index. Back Title, Annals of the Congress of the United States. Washington, 1855.

This is useful for the debates on the Oregon question. It covers 1789-1824.

United States.

Statistical View of the United States. . . . Being a Compendium of the Seventh Census, by J. D. DeBow. Washington, 1854.

Page 188 gives a brief summary of the United States' trade with China from 1790 on.

United States.

Diplomatic Correspondence of the United States of America, from the Signing of the Definite Treaty of Peace, Sept. 10, 1783, to the Adoption of the Constitution, Mar. 4, 1789. Washington, 1834.

This is used for the letters of Samuel Shaw contained in vol. 7. All of these letters are in the appendix of Shaw's Journals as well.

United States.

Executive Document No. 119, 1 Sess., 26 Cong. A message of the President, Feb. 25, 1840, in response to resolutions of Feb. 7, 1840, transmitting information about the condition of American citizens in China.

United States.

Executive Document No. 34, 26th Congress, 2d Session.

Documents giving information about the American Commerce with China conveyed by the President's message of December 29, 1840, asked for by the Resolutions of December 23d, 1840.

United States.

Executive Document No. 71, 2 Sess., 26 Congress.

This contains papers relating to the Terranova Affair.

United States.

Executive Document No. 35, 3 Sess., 27 Cong.

This is the message of the President, Dec. 30, 1842, about China and the Sandwich Islands.

United States.

Executive Document No. 40, 1 Sess., 26 Cong.

This is a memorial of R. B. Forbes and others asking for a commercial agent for China with power to negotiate a commercial treaty with China, May 25, 1839.

United States.

Executive Document No. 170, 1 Sess., 26 Cong.

This is a memorial of Thomas H. Perkins and others urging

that an armed force be sent to the China seas to protect American interests there, and that an envoy be sent to China. April, 1840.

United States.

Executive Document No. 69, 2 Sess., 26 Cong.

This contains an abstract of the Treaty of Whanghia, and some of Cushing's correspondence.

United States.

Executive Document No. 57, 1 Sess., 26 Cong.

This is a memorial of Edmund Fanning asking for an exploring expedition for the South Seas.

United States.

Executive Document No. 71, 2 Sess., 26 Cong.

This is a document of 83 pages containing a summary of the dispatches from the consuls at Canton from Nov., 1805, to June 22, 1840. They seem for the most part to be extracts from the Consular Letters, Canton (see above).

United States.

Journal of the United States in Congress Assembled. Philadelphia, ——.

These Journals of the Continental Congress throw light on early congressional action in regard to the China trade.

United States.

Reports of Committees, No. 43, 2 Sess., 24th Cong.

United States.

Reports of Committees, No. 45, 2d Session, 16th Congress.

This is Floyd's report on the Oregon question.

United States.

Register of Debates in Congress. Washington, 1825 et sqq. 1(1824-1825):11-12; 5(1828-1829):125-153, 192-195, give the debates on the occupancy of the Columbia River, bringing in references to the China trade.

United States.

James D. Richardson, A Compilation of the Messages and Papers of the Presidents, 1789-1897. Washington, 1900.

United States.

Senate Document No. 138, 2d Session, 28th Congress.

This gives copies of the instructions to the Commissioner to China (Cushing), and of the President's letter to the Emperor.

United States.

Senate Document No. 58, 2d Session, 28th Congress.

This contains an abstract of the treaty between the United States and China and some of the correspondence of Cushing.

United States.

Senate Document No. 17, 1 Session, 29th Congress.

This is a summary of the expenses of the Cushing expedition.

United States.

Senate Document No. 139, 1st Session, 29th Congress.

This contains all the correspondence between the commanders of the East India Squadron and foreign powers, and of the United States agents abroad, during the years 1842 and 1843, relating to trade and the other interests of the government, called for by the resolution of the Senate, Feb. 25, 1845.

United States.

Senate Document No. 67, 2d Session, 28th Congress.

This contains the correspondence of Cushing in regard to the treaty with China, 1844.

United States.

John H. Haswell, Treaties and Conventions Concluded between the United States of America and other Powers since July 4, 1776. Washington, 1889.

Senate Document No. 47, 2 Sess., 48 Cong.

The text of the treaty of Whanghia is on pages 145-159.

United States.

Senate Document No. 31, 1st Session, 19th Congress.

This contains various statistics in regard to the Canton trade.

Senate Document No. 306, 3d Session, 25th Congress. This is a General Statement of the goods, wares, and merchandise of Foreign Countries imported into the United States for the year ending September 30, 1838.

United States.

State Papers, 1823-4, Vol. 4, Number 73. Report of the Secretary of the Treasury of the Commerce and Navigation of the United States for the year ending September 30, 1823. Washington, 1824.

United States.

The Public Statutes at Large of the United States of America.

This is used for the copies it contains of the tariff and other laws in regard to China and the China trade, and contains as well the Treaty of Whanghia.

3. MANUSCRIPT LOGS, SHIP ACCOUNTS, BILLS OF LADING, AND KINDRED DOCUMENTS.

ACTIVE. (Ship.)

Journal of a Voyage from Salem to Sumatra and Manila, in the Ship Active, George Nichols, Master, kept by George Nichols for the use of the East India Marine Society. 1801-1803. Ms. in Journals, Vol. 2, in Essex Institute, Salem, Mass., pp. 55-135.

ANN AND HOPE. (Ship.)

Log Book of the Ann and Hope, Benjamin Page, Master, 1798-1800. Ms. in Brown and Ives Papers, John Carter Brown Library, Providence.

ANN AND HOPE. (Ship.)

Log Book of the Ann and Hope, Wilber Kelley, Master, 1818, 1819. Ms. in ibid.

ANN AND HOPE. (Ship.)

Log Book of the Ann and Hope, James Edell, Master, beginning Sept. 22, 1825. Ms. in ibid.

ANN AND HOPE. (Ship.)

Log Book of the Ann and Hope, Wilber Kelley, Master, 1817-1818. Ms. in ibid.

ANN AND HOPE. (Ship.)

Log Book of the Ship Ann and Hope, Martin Page, Master, May 30, 1823–June 28, 1824. Ms. in ibid.

ANN AND HOPE. (Ship.)

Disbursements while on three voyages to London and Canton, Christopher Bently, Master. (1801.)

In the Brown and Ives Papers, in the John Carter Brown Library, Providence. The book itemizes the various expenses connected with a voyage to China.

ARTHUR. (Ship.)

Sales Book.

In the Brown and Ives Papers, John Carter Brown Library, Providence. This shows the disposition of the goods imported in the ship Arthur from Canton, Apr. 19, 1804.

Asia. (Ship.)

Log Book of the Ship Asia, John Ormsbee, Master, July 25, 1816–circa July 1, 1818. Ms. in ibid.

Asia. (Ship.)

Log Book of the Ship Asia, John H. Ormsbee, Master, June 29, 1818–circa June 30, 1819. Ms. in ibid.

Astrea. (Ship.)

Abbreviations of a Journal of the Ship Astrea from China to Java Head on the Island of Java. One of the terminal dates is Jan. 24, 1790 (?).

Ms. in the log book of the Brig Three Sisters, Benjamin Webb, Master, 1788–1789. In Essex Institute.

Brookline. (Ship.)

Log Book of the Ship Brookline, kept by C. H. Allen, first officer, 1833–1834. Ms. in Essex Institute.

S. C. Phillips, Owner.

Brookline. (Ship.)

Journal of a Voyage of the Ship Brookline from Hamburgh to Batavia, Manila, China, Manila, and New York, in 1834-36. George Pierce, Master. Kept by Charles H. Allen, first officer. Ms. in Essex Institute.

Caravan. (Brig.)

Journal of a Voyage from the Cape Verde Islands to Canton in the Brig Caravan, James Gilchrist, Master, kept by James Gilchrist, 1807–1808.

Ms. in East India Marine Society's Journals, 6: 397-446. In Essex Institute.

Clay. (Ship.)

Journal of the Ship Clay, in a voyage from Salem to the Fiji Islands and Manila, Captain William R. Driver, 1827–1829.

Ms. in Essex Institute.

Columbia. (Ship.)

Log Book of the Ship Columbia, Captain Ro. Gray, in her Voyage from Boston to the North West Coast of America, from Sept. 28, 1790, to Feb. 20, 1792. Ms. in Department of State, Washington, D. C. In the Bureau of Rolls and Library.

Concord. (Ship.)

A Journal of a Voyage from Salem to Massafuero in the

South Pacific Ocean and from thence to Canton and back to Salem, on board the Ship Concord, Obed Wyer, Master, undertaken in the year 1799, and ending July 17, 1802. Kept by Nathaniel Appleton. Ms. in Essex Institute.

CONSUL. (Brig.)

Journal of a Voyage from New York to the South Pacific in the Brig Consul, kept by I. N. Chapman, 1834–1835.

A voyage for *beche de mer,* and other South Sea products. She went to Manila with her cargo instead of to Canton.

Ms. in Essex Institute.

DELHI. (Ship.)

Journal of a Voyage in the Ship Delhi from New York to New Orleans, New Orleans to Canton, and Canton to New York, in 1843–1844.

Ms. in Essex Institute.

DERBY. (Ship.)

Journal of a Voyage from Leghorn to Canton and Back to Boston in the Ship Derby, Thomas West, Master. Kept by Dudley S. Pickman, 1804–1806. In East India Marine Society's Journals, 5 : 133-196.

Ms. in Essex Institute.

ELIZA. (Ship.)

Journal of a Voyage of the Ship Eliza from Salem to New Zealand, Canton, and return. William Richardson, Master, 1805-1806.

Ms. in Essex Institute.

ELIZA. (Ship.)

Journal of a Voyage from Salem to New Zealand, Fijees, Manila, and return, in the Ship Eliza, Joseph Winn, Jr., Commander. May 28, 1833–May 5, 1834. Kept by John D. Winn.

Ms. in Essex Institute.

EMERALD. (Ship.)

Voyage of the Ship Emerald to the FeeJees, Tahiti, and Manila, Nov. 4, 1833–March 25, 1836. Kept by George W. Cheever.

Ms. in Essex Institute.

FRANCIS. (Ship.)

Journal of a Voyage of the Ship Francis from Salem to Leghorn, Batavia, Manila, China, and Salem. 1818–1820.

Ms. in Essex Institute.

GANGES. (Brig.)

Account of Sales of Sundries per Brig Ganges, 1810.

Bill of Lading for Brig Ganges, signed by Nathaniel Ingersoll, Salem, Sept. 2, 1809.

Mss. in Essex Institute.

GENERAL WASHINGTON.

Log Book of the General Washington, December 27, 1787–October 5, 1790.

Along with this is a fragmentary journal of the same voyage, covering May 8, 1788 to June 17, 1789.

Both manuscripts are in the Brown and Ives Papers, in the John Carter Brown Library

GLIDE. (Ship.)

Journal of a Voyage of the Ship Glide to the South Pacific Ocean. Henry Archer Jr., Master. 1829–1830. Ms. in Essex Institute.

HAMILTON. (Ship.)

Journal of a Voyage of the Ship Hamilton from Boston to the North West Coast of America and Canton, 1809–1811, 1815.

Captain Lemuel Porter. The author was possibly William Martain.

Ms. in Essex Institute.

HERALD. (Ship.)

Journal of a Voyage in the Ship Herald from Salem to Rotterdam, Canton, and Return, by Zachariah F. Silsbee (Master and Super-Cargo) in 1804–1805. Ms. in Essex Institute.

HUNTER. (Ship.)

Journal of a Voyage from Salem to Sumatra and Canton and return, 1809–1810, in the Ship Hunter. Ms. in Essex Institute.

INDUS. (Ship.)

Remarks on a Voyage from Boston to Canton by Charles Frederick Waldo, in the Ship Indus, 1802–1803. Ms. in Essex Institute. This is a private Journal kept by a common seaman.

INDUS. (Ship.)

Bill of Lading and other papers of goods on board ship Indus, Richard Wheatland, Master, Boston, March 5, 1802.

These are in the Dr. Henry Wheatland Manuscripts, in the Essex Institute, Salem, Vol. 5, p. 24.

INDUS. (Ship.)

A Journal for the above voyage, incomplete. Kept by Captain Richard Wheatland. Ms. in Essex Institute.

JOHN JAY. (Ship.)

Account Book of the Ship John Jay in 1798.

In the Brown and Ives Papers, in the John Carter Brown Library. It gives the wages of the crew.

LOUISA. (Ship.)

Bill of Lading of Ship Louisa to Northwest Coast of America, dated Oct. 5, 1826. William Martain, Master, to William Martain. In Essex Institute. (It is a loose leaf in the Log of the Louisa.)

LOUISA. (Ship.)

Journal of a Voyage of the Ship Louisa from Boston to the North West Coast of America, Canton, and Boston, William Martain, Master, 1826–1829. Ms. in Essex Institute.

MARGARET. (Ship.)

Extracts from the Log of the Ship Margaret, Commanded by Captain James Magee. Voyage to the North West Coast, 1791–1792. Typewritten copy in Essex Institute. Original owned by R. H. Derby, New York.

MERMAID. (Brig.)

Journal of a Voyage from Salem to New Zealand, the Society, Fegee, Friendly, and other Islands in the Pacific, and home by way of Manilla, and China, in the Brig Mermaid, J. H. Eagleston, Master. Oct., 1836–Apr., 1839.

With this is a journal of a cruise among the Fegee Islands in the Schooner Jane, in the employ of the Mermaid by G. N. Cheever, first officer of the brig. Unfinished.

The second part was written many years after the first, and is probably less accurate.

Mss. in Essex Institute.

MIDAS. (Ship.)

Journal of a Voyage from Salem to Canton and back, in the Ship Midas. She left Boston Sept. 13, 1818, and returning arrived in Boston Sept. 8, 1819. Ms. in Essex Institute.

MONROE. (Brig.)

Journal of a Voyage of the Brig Monroe from Boston to Africa

[Goree] to River Gambia, and to China, 1825. Samuel Vent, Commander. Kept by George W. Williams. Ms. in Essex Institute.

PALLAS. (Barque.)

Journal of a Voyage of the Barque Pallas from Salem to the Pacific Ocean, 1832–1834. Ms. in Essex Institute.

PERSEVERANCE. (Ship.)

Log Book of the Ship Perseverance in a Voyage to Batavia, Manilla, and Canton, and return, in 1796–1797, Nathaniel Hathorne, Master. Ms. in Essex Institute.

PERU. (Barque.)

Journal of a Voyage on Board the Barque Peru from Lintin to the Fijee Islands, then to Manila, 1832–1833. J. H. Eagleston, Master. Ms. in Essex Institute.

SAPPHIRE. (Ship.)

Journal of a Voyage of the Ship Sapphire from New York to Chili, Hawaii, China, Manila, and return. 1834–1835. Captain J. W. Chever. Ms. in Essex Institute.

WILLIAM. (Ship.)

Two Bills of Lading, signed by N. Emery, Jr., Mar. 25, 1809, and an Invoice of Merchandise shipped by him and Augustine Heard on Board the ship William, Noah Emery, Jr., Master, Nov. 25, 1809. In the Dr. Henry Wheatland Papers, Vol. 5, pp. 9, 10, in the Essex Institute.

WILLIAM AND HENRY. (Brig.)

Journal and Log of the Brig William and Henry from Salem, Mass., to Canton, Isle of France, and Salem, 1788–1790. Benjamin Hodges, Master. Ms. in Essex Institute.

WILLIAMS, C. H.

Journal of a Voyage from Boston to Batavia, Canton, Manila, Canton, Batavia, Saurarang, Batavia, Isle of France, and St. Helena, and the United States, begun April 16, 1836, ended Dec. 17, 1837. Commanded and kept by Charles H. Williams. Ms. in Essex Institute.

OLIVER WOLCOTT AND CO.

Store Book of Oliver Wolcott and Company, Number I. For ca. 1805. In the New York Histl. Society's Library. They did some business with Canton for themselves and other New York investors.

4. JOURNALS, DIARIES, CONTEMPORARY DESCRIPTIONS, CORRESPONDENCE, AND NARRATIVES OF VOYAGES.

Abeel, David.

Journal of a Residence in China and the Neighboring Countries, with a Preliminary Essay on the Commencement and Progress of Missions in the World. New York, 1836. (1st Ed., New York, 1834.)

This is the personal narrative, kept day by day, of the man who shares with Bridgman the honor of being the first American missionary to China.

Adams, John Quincy.

Memoirs of John Quincy Adams, Comprising Portions of His Diary from 1795 to 1848, edited by Charles Francis Adams. Philadelphia, 1876.

This is a source for the negotiations with Russia over the Northwest Coast, and for the preliminaries of the Cushing mission to China.

The American Review.

4: 392 et sqq., New York, Oct., 1846.

This is of use here for the current impressions of China.

Correspondence of the American Baptist Missionary Union.

Mss. in their rooms in Boston.

Special use has been made of the files containing the letters to and from Mrs. and Mr. Shuck, and I. J. Roberts.

Correspondence of the American Board of Commissioners of Foreign Missions.

Mss. in their Library in Boston, Mass.

See especially the files marked Foreign, vols. 1, 2, and 3, which contain the letters of the Board and of its secretaries, to the missionaries, and the two volumes marked "Correspondence from the Field," "China, 1831–1837," and "China, 1838–1844." The letters are numbered according to their order in the files.

Barnard, Charles.

A Narrative of the Sufferings and Adventures of Captain Charles W. Barnard in a Voyage Round the World during the years, 1812, 1813, 1814, 1815, and 1816. New York, 1829.

This is first hand information of the fur-sealing industry at a time when it had nearly disappeared.

BARROWS, JOHN.

Travels in China. Philadelphia, 1805.

This is given here to show that sufficient interest in China existed in America to justify an American edition of these travels.

BEECHEY, F. W.

Narrative of a Voyage to the Pacific and Bering's Strait to coöperate with the Polar Expedition performed in His Majesty's Ship Blossom under the command of Captain F. W. Beechey, R. N., in the years 1825, 1826, 1827, 1828. 2 Vols. London, 1831.

BOND, PHINEAS.

Letters of Phineas Bond, British Consul at Philadelphia, to the Foreign Office of Great Britain, 1787, 1788, 1789. Edited by the Historical Manuscripts Commission of the American Historical Association. In Annual Report of the American Historical Association for 1896. Vol. I, pp. 513-659.

These letters give some information about the beginnings of the American commerce with China, and show what opinions a well-informed British subject held in regard to it.

CAMPBELL, ARCHIBALD.

Voyage Round the World from 1806 to 1812. New York, 1817.

CLEVELAND, RICHARD J.

A Narrative of Voyages and Commercial Enterprises. 2 v. Cambridge, Mass., 1842. 2d ed., with additions, Cambridge, 1844.

Cleveland was a merchant adventurer who sailed in many seas. His voyages from Canton to the west coast of the Americas are of especial interest to us.

DELANO, AMASA.

Narrative of Voyages and Travels, in the Northern and Southern Hemispheres: Comprising Three Voyages Round the World: together with a Voyage of Survey and Discovery, in the Pacific Ocean and Oriental Islands. Boston, 1818.

Delano was largely concerned with various branches of the fur trade centering at Canton. The book is a compilation of journals kept on the voyages and is very detailed.

D'Wolf, John.

A Voyage to the North Pacific and a Journey through Siberia more than Half a Century Ago. Cambridge, Mass., 1861.

The Narrative of a Voyage from Bristol to the Northwest Coast for furs. D'Wolf, the captain, sold his vessel to the Russians, and part of the crew went to Canton. He himself went overland to European Russia. The book seems to have been written from a journal kept on the voyage. It is to be found in the Public Library, New York City.

Dix, William G.

Wreck of the Glide, with Recollections of the Fijis and of Wallis Island. New York and London, 1848.

This deals with the South Sea trade. The Glide was owned by Peabody, and sailed from Salem, May 22, 1829. The book was begun by James Oliver, of whose adventures it is a narrative, and was written by him from memory in Hawaii in 1832, shortly after the events recorded, the dates being supplied partly from the Glide's log book, and partly from the manuscripts of his companions. After Oliver's death his brother made additions from the manuscripts of shipmates.

Dixon, G.

Voyage Round the World, More particularly to the North West Coast of America. London, 1789.

This is the account of an early British voyage to the Northwest Coast.

Doolittle, Erasmus. (?)

Sketches by a Traveller. Boston, 1830.

These are letters which originally appeared in the New England Galaxy and Boston Courier. They describe a voyage to the Northwest Coast of America made probably during the War of 1812. No author's name is given, but there are some similar sketches in the same volume written by Erasmus Doolittle, and it is quite possible that he is the author of the anonymous ones. The copy in the Essex Institute has Silas Pinckney Holbrook entered in pencil as author, but the authority is not given.

Downing, C. Toogood.

The Stranger in China, or the Fan Qui's Visit to the Celestial Empire in 1836-7. 2 Vols., Philadelphia, 1838.

This is a description of Canton, Whampoa, and Macao, by an

eye-witness, an Englishman. It is also in Waldie's Select Circulating Library, Philadelphia, Part II., pp. 287-366.

ELLIOT, (CAPTAIN) ROBERT.

Views of the East, comprising India, Canton, and the Shores of the Red Sea, with Historical and Descriptive Illustrations. London, 1833.

This is of interest for its drawings, about half a dozen of which are of Chinese scenes. They were made from life in 1822, 1823, and 1824.

ERSKINE, CHARLES.

Twenty Years Before the Mast, With the More Thrilling Scenes and Incidents while circumnavigating the Globe under the Command of the late Admiral Charles Wilkes, 1836-1842. Boston, 1890.

These are the recollections of a man who had been on the voyage. They tell among other things of the massacre of the crew of the Charles Daggett of Salem on the Fiji Islands. (p. 153.) They are not very reliable.

EVERETT, EDWARD. (U. S. Minister to Great Britain.)

Letter to Daniel Webster, May 6, 1842.

Same to Same, Nov. 29, 1842. Both are in manuscript in the Bureau of Indices and Archives, State Department, Washington, D. C.

These are two letters bearing on the first Chino-British War.

FANNING, EDMUND.

Voyages to the South Seas, Indian and Pacific Oceans, China Sea, North West Coast, Feejee Islands, South Shetlands, etc., etc. New York, 1838.

This is a collection of voyages, largely taken from Fanning's own journals. It covers the years from John Paul Jones and the Serapis to 1837-8. It is largely of value here for three sketches of voyages to the South Seas for sandalwood, etc., and for its memorials to Congress.

FANNING, EDMUND.

Voyages Round the World, with selected sketches of Voyages to the South Seas, North and South Pacific Oceans, China, etc., performed under the Command and Agency of the Author. Information Relating to Important Discoveries between the Years 1792-1832. New York, 1833.

This is larger than the preceding, and contains a different set of material. It is a narrative of great value for the South Sea trade.

Fleurieu, C. P. Claret.

Voyage autour du Monde pendant les années 1790, 1791, et 1792, par Etienne Marchand, précédé d'une Introduction Historique, auquel on a joint des recherches sur les terres australes de Drake et un examen critique du voyage de Rogeneen. Paris, an. vi, (of the Republic). 6 Vols. New Ed. 4 Vol. Paris, 1841.

This is compiled from the journals of Captain Chanal and those of a surgeon who attended the vessel. It was a French expedition to the Northwest Coast.

Forbes, ——.

Personal Memoranda. In Massachusetts Historical Society, Proceedings, Vol. 7, p. 410.

Forbes, John Murray.

Letters and Recollections of John Murray Forbes. (Edited by his daughter Sarah Forbes Hughes.) Boston and New York, 1899.

Volume I, chapters 3, 4, and 5, are a good collection of first-hand material concerning the Perkins firm in Canton.

Forbes, Robert B[ennet].

Personal Reminiscences. Boston, 1878.

These are by one who was engaged in the trade.

Franchereu, Gabriel.

Narrative of a Voyage to the Northwest Coast of America, in the Years 1811, 1812, 1813, and 1814, or the First American Settlement on the Pacific. New York, 1854.

The author was a young French Canadian who went out under Astor in the "Tonquin" in 1811. There is an earlier French edition. In the Lenox Library, New York.

Gützlaff, Carl Friedrich August.

The Journal of Two Voyages Along the Coast of China in 1831 and 1832, the first in a Chinese Junk, the second in the British Ship Lord Amherst, etc. New York, 1833.

This is an account by one of the members of the party.

Hamilton, Alexander.

Hamilton's Itinerarium, Being a Narrative of a Journey from

Annapolis, Maryland, through Delaware, Pennsylvania, New York, New Jersey, Connecticut, Rhode Island, Massachusetts, and New Hampshire, from May to September, 1744. Ed. by Albert Bushnell Hart. St. Louis, 1907.

This is used here for its mention of the value of ginseng in colonial times, pp. 4, 7.

[Henshaw, J. Sidney.]

Around the World, A Narrative of a Voyage in the East India Squadron under Commodore George C. Read. New York, 1840.

This is by a participant. Vol. 2: 175-294, tells of the stay of the squadron in China.

Holmes, Samuel.

The Journal of Mr. Samuel Holmes . . . . during his attendance as one of the guard on Lord Macartney's Embassy to China and Tartary, 1792-3. London, 1798.

This is useful here for its mention of an American ship which returned part way with the expedition for protection from French privateers.

In Harvard Library.

Hunter, W. C.

Journal of Occurrences at Canton during the Cessation of Trade at Canton, 1839. Manuscript in the Boston Athenaeum.

This is an interesting first-hand account of these trying days.

Hunter, William C.

Bits of Old China. London, 1885.

This is a collection of descriptive sketches of Canton and of the factory life there, written in an entertaining way by one who knew conditions intimately.

[Hunter, William C.]

The Fan Kwae at Canton before Treaty Days, 1825-1844. London, 1882.

This is descriptive, and is much like the preceding.

Ingraham, Joseph.

An Account of a recent discovery of Seven Islands, in the South Pacific Ocean by Joseph Ingraham, citizen of Boston, and Commander of the brigantine Hope, of 70 tons burthen; and of and from this port, bound to the North West Coast of America, by permission of the owners, copied from the Journal of said

Ingraham, and communicated to the Publick, by the Historical Society.

In the Collections of the Massachusetts Historical Society, 1793, 2: 20-24.

Ingraham, Joseph.

Journal of the Voyage of the Brigantine "Hope" from Boston to the North-West Coast of America, 1790-1792. By Joseph Ingraham, Captain of the "Hope" and formerly mate of the "Columbia." In the department of Manuscripts of the Library of Congress.

This is unfinished. It is a manuscript account of one of the early American voyages to the Northwest Coast.

Jacobs, Thomas Jefferson.

Scenes, Incidents, and Adventures in the Pacific Ocean or the Islands of the Australian Seas, during the Cruise of the clipper Margaret Oakley under Captain Benjamin Morrell. New York, 1844.

This is of use for the *beche de mer* trade. It was written from a journal kept on the trip, and is by a man of some education, with a better literary style than most narratives of its kind.

Jay, John.

The Correspondence and Public Papers of John Jay, edited by Henry P. Johnson. (Putnams) New York and London, 1891.

This shows Robert Morris' part in the voyage of the "Empress of China." See especially, Vol. 3, pp. 97, 143. Writings of Thomas Jefferson. Andrew A. Lipscomb, editor-in-chief. Washington, 1904.

These give Jefferson's opinion of China on 5: 183.

Jewitt, John.

The Adventures of John Jewitt, only survivor of the Crew of the Ship Boston, during a captivity of nearly three years among the Indians of Nootka Sound in Vancouver Island. Ed. by Robert Brown. London, 1896.

Several earlier editions of this work came out. In the Historical Magazine, 4: 91, Timothy Dwight says that his uncle, Richard Alsop, wrote it for Jewitt from the latter's narrative. This was hard to use, as Jewitt was not very intelligent.

Correspondence Concerning Captain Kendrick and the Settlement of His Estate.

In the Bureau of Rolls and Library, Department of State, Washington. These also concern the Northwest Coast trade in general. Itemized, the most useful are:

(1) John Howell to Joseph Barrell, Manila, May 28, 1796.

(2) J. Barrell to John Kendrick, letter of instructions. No date.

(3) John Howell to Joseph Barrell, Macao, Dec. 23, 1796.

(4) William Sturgis to Charles Morris, Boston, Aug., 1816.

(5) T. H. Perkins to Charles Bulfinch, Boston, Dec. 21, 1817.

(6) Charles Bunfinch to W. Cushing, Dec. 1, 1816. (A printed letter.)

King, C. W., and Lay, G. T.

The Claims of Japan and Malaysia upon Christendom Exhibited in Notes of Voyages Made in 1837 from Canton in the Ship Morrison and Brig Himmaleh under Direction of the Owners. 2 Vols., New York, 1839.

Vol. I, the voyages of the Morrison, is by C. W. King, and Vol. 2, the voyage of the Himmaleh, is by G. Tradescent Lay. Both are men who participated in the events they describe.

Kotzebue, Otto von.

Voyage of discovery in the South Sea, and to Behring's Straits, in Search of a North East Passage, Undertaken in the years 1815, 1816, 1817, 1818, in the Ship Rurick. London, 1821.

In Phillips' New Voyages.

This mentions the American Northwest Fur Trade.

Kotzebue, Otto von.

A New Voyage Round the World in the Years 1823, 1824, 1825, and 1826. 2 v., London, 1830.

This mentions the American sandalwood trade in the Hawaiian Islands.

Krusenstern, (Captain) A. J. von.

Voyage Round the World in the Years 1803, 1804, 1805, 1806. By Order of His Imperial Majesty Alexander the First, on Board the Ships Nadeshda and Neva, under the command of Captain A. J. Krusenstern of the Imperial Navy. Translated from the German by Richard Belgrave Hoppner. London, 1813.

This is an account of a Russian expedition to the Northwest Coast of America, and throws light on the American trade there and at Canton.

LAPLACE, M.

Voyage autour du Monde par les Mers de l'Inde et de Chine exécuté sur la corvette de l'etat La Favorite pendant les années 1830, 1831, et 1832, sous les commandent de M. Laplace. 4 Vols. Paris, 1833.

Vol. 2 contains references to the American trade in China.

LAVOLLEE, M. C.

Voyage in Chine. Paris, 1853.

This was written by a member of the party which obtained the first French treaty with China, and is used for its mention of Parker's work.

LESSON, P.

Voyage autour du Monde enterpris par ordre du Government sur la Corvette la Coquille, par P. Lesson. Bruxelles, 1839.

This is used for the author's opinion of the work of the London Missionary Society.

LAY, G. TRADESCENT.

The Chinese as They Are. Albany, N. Y., 1843.

The fact that there was an American edition of this English work is an illustration of the interest in China felt in the United States.

LOW (MISS).

My Mother's Journal, a Young Lady's Diary of Five Years Spent in Manila, Macao, and the Cape of Good Hope, from 1829-1834. Katherine Hillard, Editor. Boston, 1900.

This diary by Miss Low gives a picture of the social life of the Americans and Europeans at Macao.

In the Essex Institute.

LOWRIE, WALTER M.

Memoirs of the Rev. Walter M. Lowrie, Missionary to China. Edited by his Father. New York, 1850.

Lowrie reached China so late that most of his work lies beyond our period.

LUTKE, FREDERIC.

Voyage autour du Monte exécuté par ordre de sa Majesté

L'Empereur Nicolas ler sur la Corvette Le Séuiavius dans les années 1826, 1827, 1828, et 1829 par Frédéric Lutké, captaine de vaisseau, aide-de-camp de s. m. l'empereur, commandant de l'expédition. Traduit par F. Boyé. 2 v., Paris, 1835.

Vol. 1, Chap. 5, mentions the American fur trade on the Northwest Coast. In the Boston Athenaeum.

MAGEE, BERNARD.

Observations on the Islands of Juan Fernandez, Massafuero, and St. Ambrose, in the South Pacific Ocean, and the Coast of Chile in South America. Extracted from the Journal of Mr. Bernard Magee, first officer of the Ship Jefferson, in her late voyage round the globe. In Collections of the Mass. Histl. Soc., 1795, 4: 247-260. Boston, 1795.

This is useful because of the first-hand information it gives concerning the fur sealing trade.

MAGEE, JAMES (CAPTAIN).

An Account of the Discovery of a Group of Islands in the North Pacific Ocean, by Captain James Magee, in the Ship Margaret, of Boston, in his run from Canton toward the North West Coast of America. Extracted from his log book.

In collections of the Mass. Histl. Soc., 1795, 4: 261-262. Boston, 1795.

This is a brief account of the discovery of what Magee named "Margaret's Islands."

MCLEOD, JOHN.

Voyage of His Majesty's Ship Alceste to China, Corea, and the Island of Lewchew with an account of her Shipwreck. London, 1819.

See especially the reference on p. 195 to the American consul at Canton.

MALCOLM, HOWARD.

Travels in South Eastern Asia, embracing Hindustan, Malaya, Siam, and China, and notices of Numerous Missionary Stations and a full account of the Burman Empire. (Preface, 1853.) Philadelphia.

These travels are too late to be of much use for our period.

MEANY, EDMOND S.

Vancouver's Discovery of Puget Sound. New York, 1907.

This consists largely of Vancouver's Journal, with long critical and explanatory notes. It is chiefly valuable for these latter.

Meares, John.

Voyages made in the Years 1788 and 1789 from China to the North West Coast of America with an introductory narrative of a voyage performed in 1786 from Bengal, etc. London, 1791.

This shows the early British trade to the Northwest Coast. Only brief mention is made of the American trade there.

Milet-Mureau, M. L. A. (Editor).

A Voyage Round the World in the Years 1785, 1786, 1787, 1788, by J. F. G. de La Pérouse. 3 v. (Trans. from the French.) London, 1798.

Some mention of American trade is to be found in these volumes.

Morrell, Benjamin (Captain).

A Narrative of Four Voyages to the South Seas, North and South Pacific Ocean, Chinese Sea, Ethiopic and Southern Atlantic Ocean, Indian and Antarctic Ocean. From the Year 1822-1831. New York, 1832.

This was apparently compiled from a journal. It contains valuable accounts of the South Sea trade, especially that in *beche de mer.*

Morrell, Abby Jane.

Narrative of a Voyage to the Ethiopic and South Atlantic Ocean, Chinese Sea, North and South Pacific Ocean in the Years 1829, 1830, 1831. By Abby Jane Morrell who accompanied her husband, Capt. Benjamin Morrell, Jr., of the schooner Antarctic. New York, 1833.

This is valuable as a side light on part of Morrell's narrative.

Moulton, William.

A Concise Extract from the Sea Journal of William Moulton written on board the Onico, in a voyage from the Port of New London in Connecticut to Staten Land in the South Seas: . . . . in the years 1799, 1800, 1801, 1802, 1803, 1804. Utica, 1804.

This gives the common sailor's side of the fur sealing trade.

Murrell, William Meacham.

Cruise of the Frigate Columbia Around the World under the

Command of Commodore George C. Read in 1838, 1839, 1840. Boston, 1840.

This is a narrative by one who was on the expedition, and is a readable description, but has no great literary merit.

In the Astor Library.

NYE, GIDEON.

The Morning of My Life in China, Comprising an outline of the History of Foreign Intercourse from the Last Year of the Regime of the Honourable East India Company, 1833, to the imprisonment of the Foreign Community in 1839. Canton, 1873.

This is a lecture by an American before the Canton Community, Jan. 31, 1873.

PATTERSON, SAMUEL.

Narrative of the Adventures and Sufferings of Samuel Patterson, experienced in the Pacific Ocean, and many other parts of the world, with an Account of the Feegee and Sandwich Islands. Palmer, May 1, 1817.

This was compiled from Patterson's papers and verbal accounts, by Ezekiel Terry, as an act of charity. It gives a common seaman's side of the sealing and fur trades.

RENOUARD DE SAINTE-CROIX, FELIX.

Voyage commercial et Politique aux Indes Orientales, aux Iles Philippines, a la Chine, avec des nations sur la Cochin Chine et le Tonquin, Pendant les années 1803-1807. 3 v., Paris, 1810.

The third volume gives an account of the affair of the Topaz and the Diana. In Harvard Library.

REYNOLDS, J. N.

Voyage of the United States Frigate Potomoc under the command of Commodore John Downes during the Circumnavigation of the Globe in the years 1831, 1832, 1833, and 1834, etc. New York, 1835.

This was compiled from the journals of R. Pinkham, S. Gordon, and Commodore Downes, who were on the cruise, and from verbal accounts of some of the crew. The author joined the expedition only twenty weeks before its close.

ROBERTS, EDMUND.

Embassy to the Eastern Courts of Cochin-China, Siam, and

Muscat, in the U. S. Sloop of War Peacock, David Geisenger, Commander, during the years 1832, 3, 4. New York, 1837.

This expedition touched at Macao.

Root, Joel.

Narrative of a Sealing and Trading Voyage in the Ship Huron, from New Haven around the World, Sept., 1802, to Oct., 1806. Read by Thomas R. Trowbridge, Nov. 26, 1888. In New Haven Historical Society Papers, Vol. 5, pp. 149-171.

This is an account of one of the fur sealing voyages which centered at Canton, and is by a participant.

Roquefeuil, M. Camille de.

A Voyage Round the World between the Years 1816-1819. London, 1823. In Vol. 9 of Richard Phillips and Co., New Voyages and Travels.

This is an account of a French voyage to the South Seas and the Northwest Coast, written by the commander of the expedition. It throws some light on American trade.

In the Astor Library.

Ruschenberger, W. S. W.

A Voyage Round the World, including an Embassy to Muscat and Siam, in 1835, 1836, and 1837. Philadelphia, 1838.

This is a narrative, rewritten from the author's own journals, of the expedition to exchange the ratification of the treaties with Siam and Muscat negotiated on Roberts' first voyage.

La Salle, A. de.

Voyage autour du Monde, Exécuté pendant les années 1836 et 1837 sur la Corvette La Bonite. Relation du Voyage, par A. de La Salle. 3 Vols. Paris, 1852.

(Shaler.)

Journal of a Voyage between China and the North Western Coast of America, made in 1804.

In the American Register or General Repository of History, Politics, and Science, Vol. 3 (1808), pp. 137-175.

Shaw, Samuel.

The Journals of Major Samuel Shaw, the first American Consul at Canton. Boston, 1847. Edited, with a life of the author, by Joseph Quincy.

This is the best source for the beginnings of American trade at Canton.

SLADE, JOHN.

Narrative of the Late Proceedings and Events in China. China, 1839.

This man, the editor of the Canton Register, is anti-Chinese and anti-American in his attitude. In this work he gives most of the official documents of all important foreign affairs in China from 1837 to the close of 1839.

SMITH, WILLIAM.

Journal of a Voyage in the Missionary Ship Duff, to the Pacific Ocean in the Years 1796, 7, 8, 9, 1800, 1, 2, etc. Comprehending Authentic and Circumstantial Narratives of the disasters which attended the first effort of the London Missionary Society. New York, 1813.

This is of use for its mention of American ships in the South Seas.

STAUNTON, (SIR) GEORGE.

An Authentic Account of an Embassy from the King of Great Britain to the Emperor of China . . . . taken chiefly from the papers of his excellency the Earl of Macartney. 2 v., London, 1798.

On 1 : 207, this account mentions some American sealers found on the Island of Amsterdam.

TAYLOR, FITCH W.

Flag Ship, or a Voyage Around the World, in the United States Frigate Columbia, Attended by Her Consort, the Sloop of War, John Adams. New York, 1840.

This is by the chaplain of the squadron.

TOMLIN, J.

Missionary Journals and Letters Written during Eleven Years' Residence and Travels amongst the Chinese, Siamese, Javanese, Khassis, and Other Eastern Nations. London, 1844.

This tells, among other things, of Tomlin's trip with Abeel to Bangkok in 1831.

TOWNSEND, EBENEZER.

The Diary of Mr. Ebenezer Townsend, Jr., the Supercargo of the Sealing Ship "Neptune" on her voyage to the South Pacific and Canton, with a preface by Thomas R. Trowbridge.

In the Papers of the New Haven Colony Historical Society, Vol. 4 (New Haven, 1888), pp. 1-115.

This is a first-hand account of one of the fur-sealing voyages.

Tyler, Lyon G.

The Letters and Times of the Tylers. Richmond, 1885.

This is of use here for Webster's part in securing Everett's appointment. The author believes that Webster wanted Everett's place.

Vancouver, (Captain) George.

A Voyage of Discovery to the North Pacific Ocean and Round the World, in which the Coast of North West America has been carefully examined and accurately surveyed, undertaken by His Majesty's Command, Principally with a view to Ascertain the existence of any navigable communication between the North Pacific and North Atlantic Oceans, and performed in the years 1790, 1791, 1792, 1793, 1794, and 1795, in the Discovery sloop of war, and armed tender Chatham under the command of Captain George Vancouver. 3 vols. London, 1798.

This was published after the death of Vancouver by his brother. It is valuable here for the information it gives concerning the early American trade to the North West Coast.

Warriner, Francis.

Cruise of the United States Frigate Potomoc Round the World during the years 1831-1834. New York, 1835.

This is an account by one of the members of the crew.

Webster, Daniel.

The Works of Daniel Webster, Boston, 1856.

These were probably compiled under the direction of Webster himself, and are especially useful in settling the authorship of certain messages and letters.

Webster, Daniel.

The Letters of Daniel Webster, from Documents owned principally by the New Hampshire Historical Society. New York, 1902. Edited by C. H. Van Tyne.

Wilkes, Charles.

Narrative of the United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842. 5 Vols., Philadelphia, 1845.

Some scattering mention of the earlier American South Sea trade which centered at Canton is to be found in this book.

Wood, W. W.

Sketches of China with Illustrations from Original Drawings. Philadelphia, 1830.

This contains a description of Canton as it was about 1830, and some pictures of scenes in or around there, made at the time.

Woodward, David.

The Narrative of Captain David Woodward and Four Seamen, who lost their ship while in a boat at sea and surrendered themselves up to the Malays in the Island of Celebes. 2d ed., London, 1805.

This is in the nature of a journal, written by Woodward, a native of Boston, Mass.

Williams, Samuel Wells.

Recollections of China Prior to 1840. In China Branch of Royal Asiatic Society's Journal, 8: 2-21. (1874.) It was read before the society Jan. 13, 1873.

5. CONTEMPORARY PAMPHLETS, SERMONS, LECTURES, DISCUSSIONS AND TREATISES.

An American Merchant. (Anonymous.)

Remarks on British Relations and Intercourse with China. London, 1834.

I have not examined the book, but have seen merely the review of it in the Chinese Repository, 3: 406.

Anonymous.

British Relations with the Chinese Empire in 1832. Comparative statement of the English and American Trade with India and Canton. London, 1832.

This is a pamphlet dedicated to the House of Lords, and is one of those issued at the time of the controversy over the East India Company's monopoly of the China trade. It is in favor of the Company, and so tries to minimize the success of the American-Chinese commerce.

In the Library of the Essex Institute.

Assey, Charles.

On the Trade to China and the Indian Archipelago with

observations on the insecurity of the British Interests in that Quarter. In Pamphleteer, Vol. 14, London, 1819, pp. 516-543. (In the Boston Athenaeum.)

Assey had been secretary to the British Government in Java, and this article shows the anxiety he had come to feel over the progress of American trade in the Far East.

Boone, William J. (M.D.).

Address in Behalf of the China Mission by the Rev. William J. Boone, M.D., Missionary of the Protestant Episcopal Church of the United States of America to China. New York, 1837.

In Boston Public Library.

(Dunn, Nathan, proprietor.)

A Descriptive Catalogue of the Chinese Collection in Philadelphia, with Miscellaneous Remarks upon the Manners, Customs, Trade, and Government of the Celestial Empire. Philadelphia, 1839.

In the Lenox Library, N. Y.

This shows the nature of this collection, brought to America for commercial purposes.

DuPonceau, Peter S. A.

Dissertation on the Nature and Character of the Chinese System of Writing. In the Transactions of the Historical and Literary Committee of the American Philosophical Society. Philadelphia, 1838. This helps to show the extent of American knowledge of China at the outbreak of the opium troubles.

Edmonds, John W.

Origin and Progress of the War between England and China. A lecture delivered before the Newburgh Lyceum, Dec. 11, 1841.

This illustrates American sentiment on the first Chinese-British War.

In Lenox Library.

Forbes, R. B.

Remarks on China and the China Trade. Boston, 1844.

In the Essex Institute.

Foster, Arnold.

Christian Progress in China. Gleanings from the Writings and Speeches of Many Workers. London, 1889.

This is largely a collection of documents, but the editing is

faulty, as Mr. Foster changed his material occasionally, omitting sentences, correcting grammatical blunders, etc.

General Association of Connecticut.

An Address of the General Association of Connecticut to the District Associations on the Subject of A Missionary Society, together with summaries and extracts from the late European publications on Missions to the Heathen. Norwich, 1797.

This is useful in tracing the beginnings of missionary enterprise in the United States.

G[reenough], W. W.

China, Its Population, Trade, and the Prospect of a Treaty. In Journal of the American Oriental Society, 1: 143-161. Boston, 1849.

Livingston, John H.

A Sermon Delivered before the New York Missionary Society at their Annual Meeting, April 3, 1804 . . . . to which are added an appendix, the Annual Report of the Directors, and other papers relating to American Missions. New York, 1804.

Used for the beginnings of American Foreign Missions.

Medhurst, W. H.

China: Its State and Prospects with especial Reference to the Spread of the Gospel, Containing Allusions to the Antiquity, Extent, Population, Civilization, Literature, and Religion of the Chinese. London, 1838.

This is used for the first-hand experiences it narrates. Although by an Englishman, it contains mention of the Americans.

Morrison, John Robert.

A Chinese Commercial Guide, Consisting of a Collection of Details Respecting Foreign Trade in China. Canton, 1834.

Nye, Gideon.

The Rationale of the China Question. Macao, 1857.

The chief interest of this for us is the reprint it contains of a letter of Mr. Nye to the New York Express, June 5, 1840, giving an account of what had happened prior to the first war with Great Britain.

Nye, Gideon.

Peking the Goal—The Sole Hope of Peace, Comprising an

Inquiry into the Origin and the Pretension of Universal Supremacy by China, and into the Causes of the First War, with Incidents of the Imprisonment of the Foreign Community and of the First Campaign of Canton, 1841. Canton, 1873.

This is by a participant, but was delivered as a lecture many years after the events narrated took place.

In the Harvard Library.

Parker, Edward Harper.

Chinese Account of the Opium War. Shanghai, 1888.

This is a translation and condensation of a work by Wei Yüan, and shows the Chinese attitude toward the Americans. In Essex Institute.

Proceedings of the Public Meeting of the India and China Trade held in the Sessions Room, Liverpool, England, on the 29th of January, 1829. The Worshipful, the Mayor, in the Chair.

Pamphlet, pp. 47. Liverpool, 1829. (?)

This gives the speeches of those opposed to the East India Company's monopoly of the Canton trade, and shows how the American trade was cited as an instance of success under free trade.

In the Harvard Library.

Reynolds, J. N.

Address on the Subject of a Surveying and Exploring Expedition to the Pacific Ocean and the South Seas Delivered in the Hall of Representatives on the Evening of April 3, 1836, by J. N. Reynolds, with Correspondence and Documents. New York, 1836.

Sheffield (Lord) [John Baker Holroyd].

Observations on the Commerce of the American States. New Edition, London, 1784.

This gives some facts about the importation into America from Great Britain of China goods just before the beginning of the trade between the United States and Canton.

Slade, John.

Notices on the British Trade to the Port of Canton, with some translations of Chinese Official Papers relative to that trade. By John Slade, late of Canton. London, 1830.

This argues for the monopoly of the East India Company, and hence tends to minimize the importance of the American trade.

In Essex Institute.

STAUNTON, (SIR) GEORGE THOMAS.

Miscellaneous Notices Relating to China, and our Commercial Intercourse with that Country, including a few translations from the Chinese Language. (2d ed., enlarged in 1822, and accompanied in 1850 by observations on the events which have affected our Chinese Commerce during that interval.) London, 1822-50.

This is favorable to the East India Company, and hence inclined to minimize the importance of American trade.

WEBSTER, DANIEL.

Speech on the Tariff in the House of Representatives April 1 and 2, 1824. In Taussig, State Papers and Speeches on the Tariff. New York, 1892.

WINES, E. C.

A Peep at China in Mr. Dunn's Chinese Collections with Miscellaneous Notices Relative to the Institutions and Customs of the Chinese and our Commercial Intercourse with Them. Philadelphia, 1839.

In Harvard Library.

This is largely a description of Dunn's Collection, and shows again the curiosity in the United States about China.

WOODS, LEONARD.

A Sermon delivered at the Tabernacle in Salem, Feb. 6, 1812, on occasion of the Ordination of the Rev. Messrs. Samuel Newell, A.M., Adoniram Judson, A.M., Samuel Nott, A.M., Gordon Hall, A.M., and Luther Rice, A.M., Missionaries to the Heathen in Asia, under the direction of the Board of Commissioners for Foreign Missions . . . . to which is added the charge by Samuel Spring, D.D., and the Right Hand of Fellowship by Samuel Worcester, D.D. Stockbridge, 1812.

6. NEWSPAPERS AND PERIODICALS.

ANGLO-CHINESE CALENDAR FOR THE YEAR OF THE CHRISTIAN AERA 1835.

Canton, China, 1834.

In Harvard Library.

Same for 1838.

In Boston Public Library.

These are useful for our purpose because of their list of the foreign residents in Canton, and some miscellaneous information.

The Baptist Missionary Magazine.

Boston, 1821, et sqq.

These files contain such first-hand information as letters from the field, journals of missionaries, etc.

The Canton Press.

Canton, China, 1835 et sqq. In the Yale Library are volumes 2, 3, and 4, and in the Astor Library are volumes 5 and part of 6. A few scattering numbers are found in with the Consular Letters, Canton. Edited by Edmund Moller. Published in Macao after July 1, 1839.

This was British in its sympathies. It ceased issue in March, 1844.

The Canton Register.

Canton, China, 1827 et sqq. In the Yale Library are volumes 3, 7, 8, 9, 10, 11, 12, and in the Astor Library is volume 4. There are a few numbers bound in with the Consular Letters, Canton. This ended its existence June 20, 1843, in Hongkong, with vol. 16 as "the Hongkong late Canton Register," which continued until 1859. Like the Press, it was British.

Chinese Courier and Canton Gazette.

This sheet was edited by an American, a son of the Philadelphia actor, Wm. B. Wood, and was opposed to the East India Company's monopoly at Canton. It endured from July, 1831, to Sept., 1833. The numbers from July 28, 1831, to April 5, 1832, are in the Boston Athenaeum.

The Chinese Repository.

Volumes 1 to 20, May, 1832, to 1851. For the origin of this periodical see above p. 107. It is indispensable for the years which it covers.

The Christian Observer.

The Beginnings of Missions in Great Britain. 40: 309.

The Columbian Centinel.

Boston, Mass., 1791-1831.

This is of use for an occasional mention of the commerce between Boston and Canton.

The Edinburgh Review.

January, 1831, Vol. 52, pp. 281-322.

Article I. Reports from the Minutes of Evidence taken before the Select Committee of the House of Lords and Commons, on the affairs of the East India Company, London, 1830.

The article is a commentary on these reports, making much of the American trade, and is hostile to the Company. It created a stir.

Hunt's Merchant Magazine.

(11:54. New York, July, 1844.) Commerce of the United States with China.

Hunt's Merchant Magazine.

(3:465. New York, December, 1840.) Commerce of China.

This was not written by a direct observer, but it was compiled from various sources which appear to have been reliable.

Hunt's Merchant Magazine.

8:205 et sqq. March, 1843. China and the Chinese Peace.

This is a contemporary's view of the subject.

Hunt's Merchant Magazine.

(2:82.)

Chinese Manufactures.

Hunt's Merchant Magazine.

(4:468.)

First American Trade with China.

Hunt's Merchant Magazine.

(12:77.)

Chronology of Events in China.

This is an excellent chronology for 1831 et sqq.

North American Review.

(40:56-68. Jan., 1835.)

Execution of an Italian at Canton.

1. London Quarterly Review for Jan., 1834, Art. vii, on Free Trade with China.

2. The Chinese Repository for Jan., 1834, Printed at Canton.

In addition to these sources, the author of the article gets

some information from a friend in Baltimore. This is a narrative of the Terranova affair.

Niles Weekly Register.

Baltimore, 1811 et sqq. (to 1849).

This contains a large number of references to China and the China trade.

The Panoplist and Missionary Magazine.

Boston. New Series, 1809-1817. For 1818, 1819, and 1820, it is called The Panoplist and Missionary Herald and beginning with 1820, it is called the Missionary Herald.

This is the magazine of the American Board of Commissioners for Foreign Missions, and contains much first-hand information, such as letters from the field, summaries of annual reports, extracts from missionary journals, etc.

The Providence Gazette and Country Journal.

Complete files are in the Rhode Island Historical Society. There are occasional references to the China trade.

The Southern Literary Messenger.

7 : 137. Richmond, 1841.

China and the Chinese.

This is a review of Davis's "The Empire of China and Its Inhabitants."

The Spirit of Missions.

Edited for the Board of Missions of the Protestant Episcopal Church in the United States of America. Burlington, N. J., 1836, New York, 1837 et sqq.

See especially the volumes for the years 1836-1844. It is of value for the Episcopal Board missions in much the same way that the Missionary Herald is for those of the American Board.

Sturgis, William.

The Northwest Fur Trade.

This was a lecture given before the Mercantile Library Association of Boston, and is condensed from the original manuscript by Elliott Cowdin, in Hunt's Merchant Magazine, 14 : 532-539. Sturgis had been to the Northwest Coast on fur trading voyages.

Williams, Samuel Wells.

Establishment of American Trade at Canton. In China Review, 5 : 152-164.

This is mainly a review of the journals of Samuel Shaw.

7. SECONDARY AUTHORITIES.

Abbott, Jacob.

China and the English, or the Character and Manners of the Chinese as Illustrated in the History of their Intercourse with Foreigners. New York, 1835.

This is a popular work written for Abbott's Fireside Series. Its sources are the writings of Marshman, Morrison, Staunton, Barrow, Auber, Milne, and others, for the most part reliable authorities.

(Anderson, Rufus.)

Memorial Volumes of the First Fifty Years of the American Board of Commissioners for Foreign Missions. Boston, 1861.

Auber, Peter.

China. An Outline of Its Government, Laws, and Policy: and of the British and Foreign Embassies, to, and Intercourse with That Empire. London, 1834.

This is by the Secretary of the Court of the Directors of the British East India Company, a man who had easy access to first-hand information. The work resembles a chronicle.

Bancroft, Hubert Howe.

History of California. 7 vols. San Francisco, 1884-1890.

This is of value for the Northwest Coast fur trade, and especially for its voluminous references to and quotations from rare sources.

Bancroft, Hubert Howe.

History of the Northwest Coast. 2 vols. San Francisco, 1884.

This is useful for the same reasons as Bancroft's History of California.

Barrett, Walter.

The Old Merchants of New York City. New York, 1870.

This was written by a man who had an intimate knowledge of much of the life which he depicted, and contains information which cannot be obtained elsewhere. It is anecdotal, uncritical, and must be used with the most extreme care.

In New York Historical Society's Library.

Becke, Louis, and Jeffery, Walter.

The Americans in the South Seas. London, 1901.

In the volume marked The Tapu of Banderah, pp. 245-258.

This seems to be based on reliable sources, although it is written in a popular style.

In Boston Athenaeum.

Bridgman, Eliza J. Gillett. (Ed.)

The Life and Labors of Elijah Coleman Bridgman, edited by Eliza J. Gillett Bridgman with an introductory note by Asa D. Smith, D.D. New York, 1864.

This is largely made up of extracts from Bridgman's private journal or diary and his correspondence, and so is very valuable.

Brown, Arthur Judson.

New Forces in Old China. New York (Revell and Co.), 1904.

This is of use here because of its brief sketch of Christian missions to China before 1807.

Bulfinch, Thomas.

Oregon and Eldorado, or Romance of the Rivers. Boston, 1866.

This gives some account of the Northwest Trade, and as the author was closely related to the Bulfinch who helped to send out the *Columbia* and the *Washington,* it should be fairly reliable for these early years.

Callahan, James Morton.

American Relations in the Pacific and the Far East, 1784-1900. In Johns Hopkins University Studies in Historical and Political Science. Baltimore, 1901.

This is disappointing, placing undue emphasis on certain minor incidents, and not at all exhausting the subject. The author is not always accurate. See above, last footnote on Chapter III.

Cary, Thomas G.

Sketch of Thomas H. Perkins. Vol. 10: 201-210. In New England Historical and Genealogical Register, Boston.

Chever, C. F.

Some Remarks on the Commerce of Salem from 1726 to 1740, with a sketch of Philip English, a merchant in Salem from about 1670 to about 1733-1734. In Historical Collections of the Essex Institute, Vol. 1, p. 67.

This helps to show the pre-Revolutionary preparation of Salem for a distant commerce, such as that to China.

Clark, Arthur H.

The Clipper Ship Era . . . . 1843-1869. New York and London, 1911.

Cleveland, H. W. S.

Voyages of a Merchant Navigator of the Days that are Past. Compiled from the Journals and Letters of the Late Richard J. Cleveland. New York, 1886.

This is an interesting supplement to R. J. Cleveland's works. It was written by his son, who adds new material and makes the voyages more readable. As he made extensive use of his father's journals and other reliable sources, the book is quite trustworthy.

In the Boston Athenaeum.

Cooper, James Fenimore.

The Crater; or Vulcan's Peak. A Tale of the Pacific. New York, 1856.

This book, although fiction, shows a knowledge of the China trade. Some references, especially those on pp. 17, 19, 20, and 35, are true to the general historical facts of the trade.

Cordier, Henri.

Histoire des Relations de la Chine avec Les Puissances Occidentales, 1860-1890. 3 Vols. Paris, 1901.

Only a very little space is devoted to the years discussed in this monograph.

Curtis, George Ticknor.

Life of Daniel Webster. New York, 1870.

Pages 2: 172-180 give an account of Webster's share in the Cushing mission. Curtis believes that Webster was not trying to get the London mission by inducing Everett to accept the China Mission.

Curtis, William Eleroy.

The United States and Foreign Powers. Meadville, Pa., 1892.

This is one of the volumes of the Chautauqua Reading Circle Literature.

Pages 250-257 give an account of the treaty of Whanghia, but are of only mediocre value.

Cushing, Lemuel.

The Genealogy of the Cushing Family. Montreal, 1877.

In the Harvard Library. This is used to show the relationship of Caleb Cushing to the Cushing engaged in the China Trade.

Cutter, William.

Missionary Efforts of the Protestant Episcopal Church in the United States. In "History of American Missions to the Heathen," pp. 563 et sqq. Worcester, 1840.

Davis, (Sir) John Francis.

China: A General Description of that Empire, and Its Inhabitants, with the History of Foreign Intercourse down to the Events which Produced the Dissolution of 1857. 2 vols. London, 1857. (New edition.)

The first half of the first volume is given to an historical sketch, and occasional mention is made of the Americans.

It was written by an Englishman who had a long, intimate knowledge of many of the events of which he spoke, and so becomes a valuable source for many events after 1816.

Dean, William.

The China Mission, Embracing a History of the Various Missions of all Denominations among the Chinese. New York, 1859.

This is of value chiefly for its large number of biographical sketches of missionaries, many of whom the author knew personally.

Eames, James Bromley.

The English in China . . . . from the Year 1600 to the Year 1843. London, 1909.

Eitel, E. J.

Europe in China. The History of Hongkong from the beginning to the year 1882. London and Hongkong, 1895.

This is of use here chiefly for diplomacy and politics.

Felt, Joseph B.

Annals of Salem. 2 vols. Salem, 1845-1849.

This is of service in determining Salem's part in the Canton trade.

Foster, John W.

American Diplomacy in the Orient. Boston and New York, 1904.

This work deals mostly with diplomacy, and with the years after 1844. It is, however, a good summary of the commercial

history, and since it is carefully done and uses good sources, such as the Consular letters from Canton, it is quite reliable. It is probably the best work previously in print that covers our period. Its chief fault is its brevity.

GAMMELL, WILLIAM.

A History of American Baptist Missions in Asia, Africa, Europe, and North America. Boston, 1849.

This was prepared at the request of the American Baptist Missionary Union.

GRAY, W. H.

A History of Oregon, 1792-1849. Portland, San Francisco, and New York, 1870.

This is not always reliable. It is of use for the Northwest Coast Fur Trade.

GRAY, EDWARD.

William Gray of Salem, Merchant. A Biographical Sketch. Boston and New York, 1914.

GREENHOW, ROBERT.

A History of Oregon and California and the Other Territories on the North West Coast of North America, Accompanied by a Geographical View and Map of Those Countries, and a Number of Documents as Proofs and Illustrations of the History. Boston, 1844.

This is used here for the Northwest Coast Fur Trade.

GRIFFIS, WILLIAM ELLIOT.

America in the East, A Glance at Our History, Prospects, Problems, and Duties in the Pacific Ocean. New York, 1890.

This touches very briefly on the period before 1844, but it is fairly good. It lacks footnote references to the authorities used, however.

GRIFFIS, WILLIAM ELLIOT.

A Maker of the New Orient. Samuel R. Brown, Pioneer Educator in China, America, and Japan. The Story of His Life and Work. F. H. Revell, New York, etc., 1902.

GÜTZLAFF, KARL FRIEDRICH AUGUST.

Gützlaff's Geschichte des Chinesischen Reiches, von den ältesten Zeite, bis auf den Frieden von Nanking. Stuttgart und Tübingen, Karl Friedrich Neumann, Editor.

There is an English translation of Gützlaff, published in two volumes in New York, 1834.

Hanson, J. W.

History of the Town of Danvers, from its Early Settlement to the Year 1848. Danvers, 1848.

Pp. 94, 111, contain notices of a ship that was built there for the East India Company for the East India trade, in 1775.

Hervey, (Rev.) G. Winfred.

The Story of Baptist Missions in Foreign Lands from the Time of Carey to the Present Time, with an Introduction by Rev. A. H. Burlingame. St. Louis, 1885.

This work is not very exact and must be used with care.

Hill, Hamilton Andrews.

The Trade and Commerce of Boston, 1630 to 1890. Boston, 1895.

In State House Library, Boston.

Hill's information about the China trade is apparently derived largely from contemporary newspapers. The book is useful for Boston's part in the trade with Canton. An article by the same man, containing much the same material, but more condensed, is in Justin Winsor's Memorial History of Boston, Boston, 1881. 4: 194-234.

Homans, J. Smith.

An Historical and Statistical Account of the Foreign Commerce of the United States. New York, 1857.

A few statistics of the Canton trade are on pp. 180, 181.

In Boston Athenaeum.

Papers Relative to Hospitals in China.

Boston, 1841.

These are simply papers telling of the work there and making an appeal for support.

In Boston Public Library.

Hunt, Freeman.

Lives of American Merchants. New York, 1856.

The ones useful here are: Thomas Handasyd Perkins, by Thomas G. Cary, and Joseph Peabody, by George Atkinson Ward.

Hunt, Freeman.

The Library of Commerce, Practical, Theoretical, and His-

torical. New York, 1845. Vol. 1, Article I. Sketch of the Commercial Intercourse of the World with China. Pp. 118-120 of this are a brief summary of the American trade with Canton, but are not very good.

In Boston Public Library.

IRELAND, ALLEYNE.

China and the Powers. Chapters in the History of Chinese Intercourse with Western Nations. Boston, 1902.

Pages 40-45 give a brief résumé of American relations before 1844, but nothing new is brought out.

In Essex Institute.

IRVING, WASHINGTON.

Astoria, or Anecdotes of an Enterprise Beyond the Rocky Mountains. 2 vols. Philadelphia, 1836.

This is the fullest and most widely known history of Astor's project.

JETER, J. B.

Memoir of Mrs. Henrietta Shuck, the First American Female Missionary to China. Boston, 1846.

This is more of a eulogy than a critical biography.

KIMBALL, GERTRUDE SELWYN.

The East India Trade of Providence. Providence, 1896.

Number 6 in the Papers from the Historical Seminar of Brown University, edited by J. Franklin Jameson.

Miss Kimball makes an extensive use of the newspapers of the times, and of various local manuscript sources.

L., H. E.

On the Trade of the United States of North America with China. In Analectic Magazine, Nov., 1819, pp. 359-366.

This is a brief sketch, rather overdrawn, compiled from conversations with various persons engaged in the trade.

LANMAN, JAMES H.

The American Fur Trade. In Hunt's Merchant Magazine, Sept., 1840, 3: 185.

This is a readable magazine sketch, but has no great historical value.

LAUT, A. C.

Vikings of the Pacific. The Adventures of the Explorers who

Came from the West, Eastward. Behring the Dane; the Outlaw Hunters of Russia; Benyowsky the Polish Pirate; Cook, and Vancouver, the English Navigators; Gray of Boston, the Discoverer of the Columbia; Drake; Ledyard, and other Soldiers of Fortune on the West Coast of America. New York, 1905.

Some good sources have been used quite extensively, and the results have been written up in an attractive style.

Leavitt, William.

Materials for the History of Ship-Building in Salem.

In Historical Collections of the Essex Institute, 7: 207.

Lindsay, W. S.

History of Merchant Shipping and Ancient Commerce. 4 v. London, 1876.

Ljungstedt, Andrew.

An Historical Sketch of the Portuguese Settlements in China, and of the Roman Catholic Church and Mission in China.

A Supplementary Chapter Descriptive of the City of Canton. Boston, 1836.

The Supplementary Chapter is the one of use to us here.

Lockhart, William.

The Medical Missionary in China. A Narrative of Twenty Years' Experience. 2d ed. London, 1861.

Lockhart gives some information about the history of medical missions before 1844, but devotes most of his space to a later period.

Loring, Charles G.

Memoir of Hon. William Sturgis.

In Proceedings of the Mass. Historical Soc., 1863-1864. Boston, 1864.

Pp. 420-473.

This is a eulogy and a character sketch, and is not very valuable for our purpose.

Lyman, Horace S.

History of Oregon. The Growth of an American State. New York, 1903. 4 vols.

This is useful for its bearing on the Northwest Coast fur trade. See especially Vol. 2, Chaps. 3, 4, 9, 10, 11.

McCulloch, J. R.

A Dictionary, Practical, Theoretical, and Historical of Com-

merce and Commercial Navigation. Philadelphia, 1847. Edited by Henry Vethake.

The section which deals with the China trade is Vol. I, pp. 293-311.

It is largely a summary of other sources, and is mostly concerned with the British trade.

MacGillivray, D. (Editor).

A Century of Protestant Missions in China, 1807-1907.

Being the Centenary Conference Historical Volume. Shanghai, 1907.

This contains some little information on this period, but nothing new.

MacPherson, David.

Annals of Commerce. London, 1805.

Mason, George C.

Reminiscences of Newport. Newport, 1884.

This is a series of papers first published in the Providence Journal and the New York Evening Post. It contains one or two notices, probably culled from newspaper files, of China ships which touched at the port.

In Harvard Library.

Massachusetts Historical Society.

The Discovery and Description of the Islands Called the Marquesas in the South Pacific Ocean. With a further account of the seven adjacent islands, discovered first by Captain Joseph Ingraham, and since by Captain Josiah Roberts. Compiled from Dalrymple's Collection of Discoveries. Cooke's Second Voyage, and the Journals and Log Book of the Ship Jefferson of Boston. In Collections of the Mass. Hist'l Soc. for 1795. 4: 238-246. Boston, 1795.

No author is given, but the article is signed, "The Above Minutes are agreeable to my observations. Josiah Roberts, and to mine, Bernard Magee." Boston, Nov. 6, 1795.

Milburn, William.

Oriental Commerce, or the East India Trader's Complete Guide. London, 1825.

This was originally compiled by William Milburn of the East India Company. A digest of his papers was made later and new material added by Thomas Thornton.

For our purposes, see XXVII, China, pp. 450-511.

Moore, John Bassett.

A Digest of International Law. Washington, 1906.

Section 797 (5:416-421) tells of the treaty of Whanghia.

Morrison, Mrs. Robert.

Memoirs of the Life and Labours of Robert Morrison, D.D., compiled by His Widow, with Critical notices of his Chinese Works by Samuel Kidd. London, 1839.

This is the standard life of Morrison.

Morse, Hosea Ballou.

The Trade and Administration of the Chinese Empire. New York, Bombay, and Calcutta, 1908.

A brief summary of American trade to 1844 is on p. 274. The general regulations of the trade at Canton before 1842 are well summarized on pp. 275-284. The author seems to refer, however, to Cooper's "Crater" as history, whereas it is the purest fiction. (p. 283.)

Morse, Hosea Ballou.

The International Relations of the Chinese Empire. The Period of Conflict, 1834-1860. London, 1910.

The most exhaustive history of the beginnings of foreign trade and diplomatic intercourse with China that has been written.

Murray, Hugh; Crawford, John; Gordon, Peter; Lynn, (Captain) Thomas; Wallace, William; Burnett, Gilbert.

An Historical and Descriptive Account of China.

3 Vols. (2d ed.) Edinburgh, 1836.

The part of this work of use to us is the chapter on commerce, 3:49-96. No authorities are given for the statistics, but they seem to be quite reliable.

Nye, Gideon.

The Opium Question and the Northern Campaigns . . . . down to the Treaty of Nanking. Canton, 1875.

Nye, Gideon.

A Century of American Commerce with China.

An Extract from the work is given in the Journal of the China Branch of the Royal Asiatic Society, 20:290-291, where it is referred to as a "forthcoming work." The book, however, does not seem to have been published.

Oberholtzer, Ellis Paxson.

Robert Morris, Patriot and Financier. New York, 1903.

Reference is made on pp. 222-224 to Morris' part in the opening of the China trade.

Osgood, Charles S., and Batchelder, H. M.

Historical Sketch of Salem, 1626-1879. Salem, 1879.

This is of value for Salem's part in the Canton trade. Much of it is from unpublished material, and hence is very useful.

Paine, Ralph D.

Ships and Sailors of Old Salem. New York, 1909.

Parton, James.

Life of John Jacob Astor, to Which is Appended a Copy of his Last Will. New York, 1865.

This contains a number of incidents concerning Astor's share in the Canton trade. It was written in a popular style and must be used with care.

Paullin, Charles Oscar.

Diplomatic Negotiations of American Naval Officers, 1778-1883. Baltimore, 1912.

Peck, Solomon.

History of the Baptist General Convention, prepared under the superintendence of Solomon Peck, Foreign Secretary of the Board. Worcester, 1840.

In the volume entitled "History of American Missions to the Heathen."

Perkins, C. C.

Memoir of James Perkins.

In Proceedings of the Mass. Hist'l Society, 1: 363-368.

This is by a son, but for our purposes does not contain much that is new.

Philip, Robert.

The Life and Opinions of the Rev. William Milne, D.D., Missionary to China. Philadelphia, 1840.

This is compiled largely from letters and original documents. It is the life of an English missionary, but gives some information on American missions to the Chinese.

Phipps, John.

A Practical Treatise on the China and Eastern Trade, Com-

prising the Commerce of Great Britain and India, particularly Bengal and Singapore with China and the Eastern Islands. Calcutta, 1835.

Such information as this contains on the American trade with China is largely obtained from the evidences printed in the Parliamentary Papers. In Boston Public Library.

Pierson, H. W. (Editor).

American Missionary Memorial, including Biographical and Historical Sketches. New York, 1853.

The Sketches in this of use here are: Origin of American Foreign Missions, by Rev. S. M. Worcester, D.D.; and David Abeel, by Rev. T. E. Vermilye.

Pitkin, Timothy.

Statistical View of the Commerce of the United States of America. Hartford, 1816.

This is a very useful work, and as a rule employs excellent sources. See especially pp. 208-211, 166-207. In Boston Athenaeum.

A later edition of this, New Haven, 1835, contains some more recent material. It omits, however, some statistics contained in the earlier edition. Both are of service.

Preble, George Henry.

Notes on Early Ship-Building in Massachusetts.

Communicated to New England Historical and Genealogical Register, 1871.

In Boston Public Library.

This tells of the building of an East Indiaman in America in 1775.

Preble, George Henry.

The First Cruise of the United States Frigate Essex.

In Historical Collections of the Essex Institute, 10: 34 et sqq.

Rantoul, Robert S.

The Port of Salem.

In Historical Collections of the Essex Institute, 10: 52 et sqq.

Reid, J. M.

Missions and Missionary Society of the Methodist Episcopal Church, by J. M. Reid, revised and extended by J. T. Gracey, D.D. 3 vols. New York, c. 1895.

Richardson, F. A., and Bennett, W. A.

Baltimore Past and Present, with Biographical Sketches of its Representative Men. Baltimore, 1871.

This contains an Historical Sketch of the city by H. Mayer, a former president of the Maryland Historical Society, and it is this which is of use here.

Ritter, Abraham.

Philadelphia and Her Merchants as Constituted Fifty to Seventy Years ago. Philadelphia, 1860.

This contains quite a mass of material useful for Philadelphia's share in the China trade. It is drawn largely from the memory of the author and of his acquaintances, and must be used with care. In the Astor Library.

Saltonstall, Leverett.

Memoir of Robert Bennett Forbes.

In Mass. Hist'l Society's Proceedings, 2d series, 6: 197-202.

This seems to be drawn largely from Forbes' published works.

Sargent, A. J.

Anglo-Chinese Commerce and Diplomacy. (Mainly in the Nineteenth Century.) Oxford, 1907.

This contains occasional mention of early American trade with China. See especially pp. 18, 19, 29, 30, 41.

Schouler, James.

History of the United States of America under the Constitution. Volume IV, 1831-1841. Washington, 1889.

This gives on pages 436, 437, an account of Cushing's appointment, unfavorable to Webster.

Schuyler, Eugene.

American Diplomacy and the Furtherance of Commerce. New York, 1886.

There is a summary of the diplomacy over the Russian advances on the Northwest Coast on pages 292-305.

In the Boston Athenaeum.

Seybert, Adam.

Statistical Annals: Embracing Views of the Population, Commerce, Navigation, Fisheries, Public Lands, Post Office Establishment, Revenues, Mint . . . . of the United States of America, founded on Official Documents. Philadelphia, 1818.

This covers March 4, 1789, to April 20, 1818, and contains some material which is not to be found in print elsewhere.

[Sparks, Jared.]

Travels and Adventures of John Ledyard, Comprising his voyage with Captain Cook's third and last expedition, his journey on foot 1300 miles round the Gulf of Bothnia to St. Petersburg, his adventures and residence in Siberia, and his exploring mission to Africa. London, 1834. (Earliest ed., Cambridge, 1828.)

This throws light on Ledyard's share in beginning the Northwest Coast Fur Trade.

Speer, William.

The Oldest and the Newest Empire. China and the United States. Hartford, Conn., 1870.

The author had been a missionary to China and to the Chinese in California. Pages 410-420 cover the period of this monograph. He seldom quotes authorities, although one could wish that he had done so, especially for his statement about the beginnings of American trade to Canton.

In the Library of Columbia University.

Stevens, George B. (Rev.), with the Coöperation of Rev. W. Fisher Markwick.

The Life, Letters, and Journals of the Rev. and Hon. Peter Parker, M.D., Missionary, Physician, and Diplomatist, the Father of Medical Missions and Founder of the Ophthalmic Hospital in Canton. Boston and Chicago, c. 1896.

This contains many quotations from Parker's letters and journals.

Stevens, John Austin.

Progress of New York in a Century, 1776-1876. An address delivered before the New York Historical Society, Dec. 7, 1875. New York, 1876.

He only briefly mentions the China trade of New York.

In New York Historical Society's Library.

Sumner, William Graham.

The Financier and the Finances of the American Revolution. 2 vols. New York, 1892.

See references on 2: 163, 277, for Morris' connection with the Canton trade.

Thomson, (Rev.) William.

Memoirs of the Rev. Samuel Munson, and the Rev. Henry Lyman, Late Missionaries to the Indian Archipelago with the Journal of their Exploring Tour. New York, 1839.

This is valuable chiefly for its use of good contemporary sources.

Tracy, Joseph.

History of the American Board of Commissioners for Foreign Missions. Worcester, 1840.

In a volume, "History of American Missions to the Heathen," etc.

He has used quite extensively a number of sources, which he quotes.

Trow, Charles E.

The Old Shipmasters of Salem. New York and London, 1905.

This is used for Salem's share in the China Commerce.

Trowbridge, Thomas Rutherford.

History of the Ancient Maritime Interests of New Haven. New Haven, 1882.

Chapter vii is on the maritime enterprise of New Haven in the South Seas.

(This is also in New Haven Colony Hist'l Soc. Papers, Vol. 3: 85-204.)

Trowbridge, Thomas R.

Grandfather's Voyage around the World in the Ship "Betsey." 1799-1801. New Haven, 1895.

The author says, "In 1853, four years after the death of my grandfather, my father carefully and patiently related the voyage to me. I wrote it down word for word in a book which I have carefully preserved." This book was made up from the account thus written. It was another of the fur sealing voyages. There is a summary of the same voyage in "The Trowbridge Family, or Descendants of Thomas Trowbridge," by F. W. Chapman. New Haven, 1872, pp. 69-72.

Trumbull, H. Clay.

Old Time Student Volunteers. My Memories of Missionaries New York, 1902.

This is composed of brief biographies of early missionaries with occasional reminiscences.

TUFTS, WILLIAM.

Account of the Vessels Engaged in the Sea-otter Fur Trade on the Northwest Coast Prior to 1808.

In James G. Swan, The Northwest Coast, or Three Years' Residence in Washington Territory. New York, 1857. Pp. 423-425.

This was compiled from his own memoranda and from notes furnished by Captain Sturgis. It is valuable as a list, although an incomplete one, of the trading voyages to the Northwest Coast.

WARDEN, D. B.

Description Statistique, Historique et Politique des Etats-Unis de l'Amérique Septentrionale depuis l'époque des premiers établishemens jusqu'a nos jours. Traduite sur celle d'angleterre. 5 vols. Paris, 1820.

5: 595, 596, 597, gives a brief statement of the American tea trade with China.

WEEDEN, WILLIAM B.

Economic and Social History of New England, 1620-1789. 2 vols. Boston and New York, 1890. 2: 820-828, gives some information about the beginnings of the Canton Trade, much of it from very good sources, and some from rare manuscripts.

WEEDEN, WILLIAM B.

Early Oriental Commerce in Providence.

In Mass. Hist'l Soc. Proceedings, 3d Series, 1: 236-278. Boston, 1908.

This is a rather ill-digested collection of notes from various sources, largely the Brown and Ives papers in the John Carter Brown Library.

WHEELER, L. N.

The Foreigner in China. With introduction by Prof. W. C. Sawyer. Chicago, 1881.

This is written in a popular style, showing no great research, and has only one or two pages on the period covered by this monograph.

Williams, Frederick Wells.

The Life and Letters of Samuel Wells Williams, LL.D., Missionary, Diplomatist, Sinologue. New York, 1889.

This is written largely from letters and other good sources, and by a son.

Williams, Samuel Wells and Frederick Wells.

A History of China, being the Historical Chapters from the "Middle Kingdom." New York City, 1901.

This is especially complete on European intercourse with China.

Williams, Samuel Wells.

The Middle Kingdom. A Survey of the Geography, Government, Literature, Social Life, Arts, and History of the Chinese Empire and Its Inhabitants. 2 vols. New York, 1883 (Reimpression, 1904).

Although rather old, this is still a standard reference book on China.

It covers too broad a field to go much into detail, but what it gives is good, especially on missions, and on diplomatic history, much of which the author knew as a participant.

Williamson, C. R.

Memoir of Rev. David Abeel, D.D., Late Missionary to China. New York, 1848.

This was written more for edification than history, but it is valuable because it contains large extracts from Abeel's journals of earlier and of later dates than those published under his own name.

(Wilson, T. L. V.) (?)

The Aristocracy of Boston, Who they are, and what they are, being a History of the Business and Business Men of Boston for the Last Forty Years. By One who knows Them. Boston, 1848.

This is a collection of short reminiscent accounts. It must be used with care.

Winsor, Justin, (Editor).

Narrative and Critical History of America. Boston and New York, c. 1888.

An article by James B. Angell gives on 7: 510 an account of the negotiations with Russia over the Northwest Coast.

[Wylie, Alexander.]

Memorials of Protestant Missionaries to the Chinese Giving a List of their Publications and Obituary Notices of the Deceased. Shanghai, 1867.

This contains fairly good brief biographies of most of the men.

Yule, Henry.

Cathay and the Way Thither, being a Collection of Medieval Notices of China, translated and edited by Colonel Henry Yule, with a preliminary essay on the intercourse between China and the Western Nations Previous to the discovery of the Cape Route. London, Hakluyt Society, 1866.

This is the best single work on medieval intercourse between China and Europe. It is used here to give information for a brief sketch of Western intercourse with China prior to the coming of the Americans.

INDEX.

Abeel, David, 89, 90, 92, 99, 104, 106, 108, 160, 173, 194, 199.
"Active", 40, 45, 154.
Adams, John Quincy, 38, 55, 125, 129, 130, 131.
Ah Loo, 97.
"Akbar", 70.
"Alceste", 169.
"Alexander", 36.
Allen, Charles H., 155.
"Alliance", 14, 16.
American Baptist Board of Foreign Missions, 87, 96, 106, 160, 187, 188, 193.
American Bible Society, 86, 88.
American Board of Commissioners for Foreign Missions, 8, 86, 89, 92, 94, 105, 106, 122, 146, 160, 182, 183, 197.
American Oriental Society, 136.
American Philosophical Society, 124.
American Seaman's Friend Society, 89, 93, 149.
American Tract Society, 88, 146.
Amoy, 120, 140.
Amsterdam, 45.
Amsterdam, Island of, 39.
Andover Theological Seminary, 86.
Anglo-Chinese College at Malacca, 88.
"Ann and Hope", 22, 46, 47, 49, 154.
"Ann McKinn", 70.
Appleton, Nathaniel, 156.
Archer, Henry, Jr., 157.
Archer, Jones, Oakford and Company, 70.
Ariel, 119.
"Arthur", 46, 154.
"Asia", 18, 155.
Astor, John Jacob, 37, 42, 43, 52, 68, 189, 193.
Astoria, 42, 56.
"Astrea", 18, 65, 155.
"Atahualpa", 36.
Austin, Elijah, 39.
Australia, 14, 16, 40, 45, 46.
Austrians, 31.

Ball, Dyer, 105.
Ball, J. D., 120.
Baltimore, 50, 60, 70.
Bangkok, 96, 103, 104, 105, 106, 173.
Banksall, 22.
Baptist Missionary Society, 8.
Barnard, Charles, 160.
Barrell, Joseph, 31, 167.
Barry, Captain, 18.
Bass, 66.
Batavia, 45, 46, 72, 88, 91, 95, 103, 104, 107, 108, 156, 159.
Battaks, 108.
Baylies, 57.
"Beaver", 43.
beche de mer, 8, 43, 53, 58-60, 156.
Beechey, F. W., 161.
Benham, 107.
Bentley, Christopher, 154.
Benton, Thomas H., 131, 133, 146.
Bering, 30.
"Betsey", 197.
Biddle, Commodore, 144.
Bills of exchange, 71.
Bird's nests, edible, 43.
Blockade of Canton by British, 114.
"Blossom", 161.
Bocca Tigris, 22, 23, 25, 48.
Bombay, 45, 46.
Bond, Phineas, 12, 74, 161.
Boone, William J., 109, 120, 122, 176.
Borneo, 92, 105.
Boston, 13, 15, 18, 30, 31, 34, 35, 41, 64, 156-158, 188.

"Boston", 36, 166.
Botany Bay, 45, 46.
"Boxer", 84.
Bradley, 106.
"Brandywine", 134, 136.
Brazil, 77.
Bridgman, Elijah C., 89, 90, 91, 93, 99, 105, 115, 120, 139.
Bristol, 35, 67.
British and Foreign Bible Society, 86, 104.
British Manufacturers, 73.
British Northwest Fur Company, 37, 43.
"Brookline", 155.
Brown, John, 17.
Brown, Samuel, 31.
Brown, Samuel R., 99, 101, 187.
Brown and Francis, 17, 28.
Brown and Ives, 8.
Brumley, Reuben, 44.
Bryant and Sturgis, 66.
Bulfinch, Charles, 31.

Cabot, Samuel, 66.
Calcutta, 28, 39, 45, 51.
California, trading and sealing voyages to, 36.
Campbell, Archibald, 161.
Canton, 10, 14, 18, 33-35, 39, 46, 66, 122, 140.
"Canton", 14, 17, 18.
Canton-American trade, decline in 1826, 63.
Canton commercial system before 1842, 18, 26.
Canton, community life in, 82.
Canton General Chamber of Commerce, 82.
Canton, growth of trade with, 1789-1810, 48.
"Canton Press", 82, 180.
Canton Regatta Club, 82.
"Canton Register", 82, 180.
Cape of Good Hope, 13, 14, 17, 32, 35, 39, 45.
Cape Verde Islands, 14, 45, 155.
"Caravan", 155.
Carey, William, 86.
Carolinas, 11.
"Caroline", 50.
Carrington, Edward, 50, 88.
Cary, Thomas G., 188.
Cassia, 80.
Celebes, 175.
Chapman, I. N., 156.
"Charles Daggett", 59, 163.
Charleston, 70.
Cheever, G. N., 158.
Cheever, George W., 156.
Cheever, J. W., 159.
Chile, 159, 169.
China ware, 80.
Chinese Courier and Canton Gazette, 180.
Chinese in the United States, 123.
Chinese Repository, 9, 91, 100, 127, 146, 180.
Ching, 136, 137, 138.
Chop, 22.
Chrestomathy, 99, 116.
Christian Union of Canton, 92, 99.
Church Missionary Society, 85.
Chusan, 122.
Clark, John I., 67.
Clark and Nightingale, 67.
"Clay", 59, 155.
Cleveland, Richard J., 24, 36, 46, 161, 185.
Clipper ships, 70.
Co-hong, 20, 62, 82, 119, 140.
Colden, 57.
"Columbia", 12, 14, 22, 23, 65, 155, 166, 173.
Columbia River, 38, 56, 152.
Columbus and China, 10.
Comprador, 22.
Conception, 41.
"Concord", 155.
"Congress", 83.
Connecticut, 13.
Connecticut, General Association of, 85, 177.
"Constellation", 117.
"Consul", 156.

Consulate at Canton, American, 16.
Cook, Captain, 30, 31.
Cooledge, T. R., 35, 94, 102, 116.
Coolidge, J., 66.
Copper, 72.
"Coquille", 168.
Corlis, John, 67.
Cotton, 72, 76.
Cowpland, 60.
Cummings, W. H., 122.
Cushing, Caleb, 126, 129, 133-144, 152, 153.
Cushing, John P., 66, 134.

Daniel Parker and Company, 13.
Danvers, 10.
Daschkoff, 37, 38.
Davis, William H., 44.
Dean, William, 96, 106, 121.
Deane, Stewart, 16.
Delano, Amasa, 39, 40, 161.
Delano, Warren, Jr., 114, 118.
"Delhi", 72, 156.
Dennison, Captain, 17.
"Derby", 46, 156.
Derby, Elias H., 17, 64, 65, 145.
Derby, John, 31.
D'Wolf, John, 35, 36, 67, 162.
"Diana", 51.
Dickinson, J. T., 105.
Diffusion of Useful Knowledge in China, Society, 100.
Diver, W. B., 102, 115.
Dix, W. G., 162.
Dixon, G., 162.
Domestic and Foreign Missionary Society of the Protestant Episcopal Church in the U. S. A., 87, 109, 149.
Doolittle, Erasmus, 162.
"Doris", 52.
Dorr and Sons, 35, 66.
Doty, Elihu, 108.
Douglas, 32, 34.
Downes, John, 171.
Driver, William, 59, 155.
"Duff", 173.
"Duke", 44.
Dunn, Nathan, 176, 179.
Dutch Reformed Church, 89, 96.
Duties, Chinese customs, 23.
Dyer, Samuel, 88.

Eagleston, J. H., 158, 159.
East India Company, British, 10, 12, 54, 88, 96, 110, 127, 147, 148, 171, 178, 179, 181; effect of American trade upon, 74-76.
East India Company, Danish, 18.
"Eclipse", 37, 65.
Edell, James, 154.
Edmonds, John W., 125.
Edward Carrington and Company, 67.
"Eleonora", 18, 34, 39.
"Eliza", 39, 46, 59, 156.
Elliot, Captain, 113, 116.
"Emerald", 59, 156.
Emery, N., Jr., 159.
"Emily", 60, 61, 111.
Emperor's merchant, 20.
"Empress of China", 13-17, 30, 69.
England, 73.
English, 14; trade with Northwest Coast, 31.
English Baptist Missionary Society, 85.
English, Philip, 184.
Episcopal Board. See Domestic and Foreign Missionary Society of the Protestant Episcopal Church in the U. S. A.
Erskine, Charles, 163.
"Essex", 194.
Essex Institute, 8.
Everett, Edward, 126, 132.
Exterritoriality, 141.
Eyre and Massey, 69.

Factories at Canton, 20, 24.
Factory, American, at Canton, 81.
"Fair American", 35.
Falkland Islands, 30, 39.
Fanning, Edmund, 51, 152, 163.
Fanning, H., 69.

Fanning's Island, 60.
Fiji Islands, 44, 58, 155, 156, 158, 162, 163, 171.
Floyd, 56, 152.
Foochow, 140.
Forbes, John M., 66, 70, 71, 164.
Forbes, Paul S., 136, 137.
Forbes, Robert B., 66, 164, 195.
Forbes, Thomas T., 66.
France, 14, 77.
Franchereu, Gabriel, 164.
"Francis", 156.
Frazer, Captain, 104.
Friendly Islands, 158.
"Friendship", 83.
Fuhkien, 95.
Fur-sealing in the South Seas, 38-43.
Fur trade, 8, 29-43, 53.

Gambia River, 159.
"Ganges", 157.
"General Washington", 14, 17, 67, 157.
Gibraltar, 71, 73, 77.
Gilchrist, James, 155.
Ginseng, 10, 14, 27, 29, 73.
Girard, Stephen, 70.
"Glide", 59, 157, 162.
Goddard, Josiah, 107.
Gordon, S., 171.
"Grand Turk", 17, 64.
Gray, J., 66.
Gray, Robert, 155.
Green, John, 13, 16.
Grosvenor, consul at Canton, 127.
Gützlaff, K. F. A., 94, 98, 106, 164, 187.
Gützlaff, Mrs., 101.

Hadley, Lady, 39.
Hainan, 97.
Hall, 87.
Hamburg, 45, 46, 77, 155.
"Hamilton", 157.
"Hanover", 67.
Hanson, F. R., 109.
Hartford, 41, 68.
Hatch, Crowell, 31.
Hathorne, Nathaniel, 46, 159.
Hawaii, 34, 35, 42-44, 57, 151, 159, 171.
"Hazard", 36.
Heard, Augustine, 159.
Henshaw, 128.
"Herald", 157.
"Himaleh", 104.
Hobson, Benjamin, 103.
Hodges, Benjamin, 22, 159.
Holland, 77.
Hong merchants. See co-hong.
Hongkong, 113, 114, 120, 122, 139, 186.
Hong Sheung. See co-hong.
"Hope", 14, 16, 33, 44, 45, 66, 105, 166.
Hoppin, Benjamin and Son, 67.
Hoppo, 14, 22.
Howell, John, 167.
Howqua, 21, 102.
Hoy and Thorn, 66.
Hudson Bay Company, 98.
"Hunter", 46, 157.
Hunter, W. C., 165.
Hunt's Merchant Magazine, 125.
"Huron", 95, 172.

Impressment of American sailors by British, 49-51.
India, 7.
"Indus", 46, 157.
Ingersoll, Nathaniel, 157.
Ingraham, Joseph, 33, 66, 165, 191.
Innes, 112.
Irving, Washington, 31.
Isle of France, 39, 45, 159.

Jackson, Andrew, 84.
"Jacob Jones", 52.
Jacobs, T. J., 166.
"Jane", 158.
Japan and Japanese, 98, 115.
Jardine, 82.
Java, 155.
Jay, John, 13, 15.
"Jefferson", 34, 169.

Jefferson, Thomas, 124.
"Jenny", 18.
Jewitt, John, 166.
"John Adams", 173.
John Carter Brown Library of American History, 8.
"John Jay", 45, 46, 158.
Johnson, Stephen, 106, 108.
Jones and Clark, 69.
Jones, John Paul, 31.
Jones, John T., 106.
Juan Fernandez, 169.
Judson, Adoniram, 87.
"June", 36.

Kagoshima, 98.
Kamchatka, 37, 42.
Ke, 118, 119, 136-140, 143.
Kearney, Commodore, 116, 117, 118.
Kelley, Wilbur, 154.
Kempton, Captain, 51.
Kendrick, John, 12, 32, 43, 167.
King, C. W., 98, 99, 113.
King George's Sound Company, 32.
Kiying. See Ke.
Kodiack Indians, 55.
Kotow, question of, 135.
Kotzebue, 57.
Krusenstern, A. J. von, 46, 167.

"Lady Washington", 14, 32, 33.
"La Favorite", 168.
Lamb, 35, 66.
Laplace, M., 168.
Lay, G. T., 104.
Lead, 73.
"Leander", 65.
Leang Afa, 88, 93.
Ledyard, John, 30, 190, 196.
Leghorn, 45, 46, 156.
"Lelia Byrd", 36.
Lepers, 98.
Lew Chew Islands, 98.
Lin Tse-sü, 112, 113, 115, 128.
Linguist, 22.
Lintin, 25, 81, 83, 84, 111, 159.
Lisbon, 46.
Livingston, John H., 177.
Lockhart, William, 102.
Lockwood, Henry, 109.
London, 154.
London Missionary Society, 85, 95, 102, 108, 173.
"Lord Amherst", 164.
"Louisa", 35, 158.
Lowrie, Walter M., 121.
Lutke, F., 168.
Lyman, Henry, 35, 108, 197.
Lymans, 66.

Macao, 7, 20, 22, 25, 49, 50, 81, 82, 91, 97, 98, 101, 113, 115, 122, 136, 168.
Macartney Mission, 39, 165, 173.
Macgowan, Daniel J., 122.
McRea, John, 70.
Madagascar, 11.
Madras, 17.
Magee, Bernard, 169.
Magee, James, 16, 18, 34, 39, 66, 158, 169.
Malacca, 87, 101.
Malay Peninsula, 90.
Manchus, 19.
Manila, 45, 58, 59, 66, 72, 118, 154-156, 159, 168.
Marchand, Etienne, 164.
"Margaret", 34, 47, 158, 169.
"Margaret Oakley", 60, 166.
Marquesas Islands, 33, 58, 191.
Martain, William, 157, 158.
"Massachusetts", 18.
Massachusetts, 11.
Massachusetts Missionary Society, 86.
Massafuero, 39-42, 155.
Mauritius. See Isle of France.
Meares, John, 32, 170.
Medhurst, W. H., 88, 94, 95, 107, 177.
Medical Missionary Society in China, 102, 122.
Mediterranean, 11.
Melon, 44.
"Mercury", 36.

"Mermaid", 59, 158.
Metcalf, Captain, 18, 34, 35.
Methodist Missionary Society, 87, 96.
Miller, 117.
Milne, William, 87, 88, 193.
Milner and Bull, 81, 88.
Missionary Herald, 88.
Missions, origin of in America, 85.
Missions, after first Chinese-British war, 120.
"Missouri", 134, 136.
Mongol conquests, 7.
"Monroe", 158.
Morrell, Benjamin, 59, 166.
Morris, Charles, 167.
Morris, Robert, 13, 15, 16, 30, 69, 193.
"Morrison", 93, 98, 116.
Morrison, J. R., 95, 177.
Morrison, Robert, 61, 87, 88, 90, 94, 95, 99, 101, 192.
Morrison Education Society, 101, 122.
Moulton, William, 170.
Munson, Samuel, 108, 197.

Nagasaki, 98.
Nankeens, 53, 80.
Nanking, treaty of, 119, 120, 126, 130.
Napier, Lord, 93, 110.
"Nautilus", 42.
"Neptune", 39, 41, 173.
Nevius, Elbert, 108.
Newell, 87.
New China Street, 25.
New Haven, 38, 39, 64, 68, 197.
New London, 30, 38, 41, 68.
New Orleans, 156.
Newport, 67, 191.
Newton, J. W., 93.
New York, 11, 13, 15, 18, 30, 35, 39, 40, 41, 44, 64, 68, 155, 156.
New York Custom House, 148.
New York Missionary Society, 177.
New Zealand, 46, 156, 158.
Nichols, George, 40, 154.
Nicol, William, 50.
Niles Register, 123, 135.
Ningpo, 20, 140.
Nootka Sound, 32, 33, 34.
Norfolk Island, 46.
Northwest Coast, 158, 164, 167, 172, 184.
Northwest Coast fur trade, 29, 54, 55, 195, 198.
Norwich, 64.
Nott, 87.
Nutmegs, 73.
Nye, Gideon, 127.

O'Cain, 36.
Officials, Chinese, communication of foreigners with, 25.
Old China Street, 25.
Oliver Wolcott and Company, 68, 159.
Olyphant, D. W. C., 69, 89, 90, 92, 95, 102.
Olyphant and Company, 69, 81, 95, 98, 104, 117.
Ophthalmic Hospital, 94, 99, 102.
Opium, 23, 27, 72, 73, 95, 111-114, 118, 119, 192.
Oregon, 32, 56, 57, 152, 187.
Ormsbee, John, 155.
"Outside merchants", 21.

Page, Benjamin, 46, 154.
Page, Martin, 154.
"Pallas", 15, 59, 159.
Panoplist and Missionary Magazine, 182.
Parish, Thomas, 66.
Parker, Commodore, 134.
Parker, Peter, 94, 97, 98, 102, 104, 115, 121, 128, 129, 139, 188, 196.
Patterson, Samuel, 171.
Peabody, Joseph, 65, 188.
"Peacock", 83, 84.
Pearl River, 20, 22.
Pearls, 59.
Peet, 107.

Peking, 136.
Pellew, Commodore, 51.
Pepper, 73.
Perkins, James, 193.
Perkins, James and Thomas H., 37, 66.
Perkins, Thomas H., 18, 33, 55, 65, 151, 184, 188.
"Perseverance", 46, 159.
"Peru", 59, 159.
"Phaeton", 50, 51.
Philadelphia, 16, 35, 39, 41, 64, 86.
Pickman, Dudley S., 46.
Pilots' fees, 23.
Pinkham, R., 171.
Pintard, John M., 31.
Pirates, 11, 48.
Pohlman, W. J., 105, 108.
"Polly", 34.
Pondicherry, 17.
Porter, Lemuel, 157.
Portugal, 7, 11, 19, 51, 71, 85.
"Potomac", 83, 171, 174.
"President Washington", 28.
Presbyterian Board, 105, 121.
Presbyterian Church, 96.
Privateers, 11, 17, 49.
Providence, 11, 17, 35, 46, 64, 67, 198.
Providence Custom House, 149.

Quallah Battoo, 83.
Quicksilver, 72.

"Rambler", 52.
Randall, 15.
Rattans, 73.
Read, Commodore George C., 128, 165.
Reed, Alanson, 107.
Reid, Thomas, 16.
Revolution, American, 12.
Rhode Island, 11.
Rice, 23, 72, 87.
Richardson, William, 46, 156.
Roberts, Edmund, 83, 84.
Roberts Fund and China Mission Society, 98.
Roberts, Issacher J., 97, 120, 121.
Roberts, Joseph, 34.
Roberts, Josiah, 191.
Robinson, 106, 108.
Rogers, T., 97..
Roman Catholic Missions in China, 90, 190.
Romanzoff, 37, 38.
Root, Joel, 41, 172.
Rotterdam, 157.
Russell and Company, 71.
Russell, Sturgis and Company, 81.
Russia and Russians, 30, 36, 37, 54, 77.
Russian-American Negotiations over Northwest Coast, 37, 38, 55, 56.

St. Ambrose, 39, 169.
St. Helena, 159.
"St. Louis", 134.
St. Paul Island, 40.
St. Petersburg, 45, 46.
Salem, 11, 13, 17, 39, 41, 46, 58, 59, 64, 65, 154-158, 184, 186, 190, 193, 194, 197.
Salem Custom House, 149.
Salt peter, 23.
Salter, John, 36.
Samuel Russell and Company, 81.
Sandalwood, 8, 43, 53, 57, 58.
Sandalwood Bay, 60.
Sandwich Islands. See Hawaii.
"Sapphire", 159.
Saurarang, 159.
Scotch Missionary Society, 85.
Seaman's Friend Association of China, 103.
Sea Otter, 30.
"Semiramis", 67.
Serampore, translation of the Bible, 88.
Shaler, 36.
Shanghai, 95, 140.
Shantung, 95.
Sharks' fins, 43.
Shaw and Randall, 81.
Shaw, Samuel, 14, 15, 16, 18, 151.

Sherry, 116, 117, 143.
Shuck, Henrietta Hall, 96, 116, 189.
Shuck, J. Lewis, 96, 97, 98.
Siam, 90, 105, 106.
Silk, 27, 53, 76, 79.
Silsbee, Z. F., 157.
Singapore, 94, 96, 97, 103, 104, 105.
Sitka, 36.
Slade, John, 173.
Slater, 108.
Smith, Thomas H., 63, 69.
Smuggling into China, 23.
Snow, P. W., 25, 81, 113, 114.
Snow, Samuel, 49.
Society Islands, 158.
South America, 30, 71, 72.
South Georgia, 39.
South Seas, 30, 43-45, 152, 178, 183.
South Shetland Islands, 163.
Specie, 23, 27, 28, 71.
Spirit of Missions, 182.
Stacker, John C., 70.
"States", 39.
Stevens, Edwin, 92, 94, 95, 101, 104.
Stewart, William R., 39.
Stonington, 38, 42, 64, 68.
Sturgis, James P., 66, 82.
Sturgis, William, 34, 47, 167, 182, 190.
Sue Anam, 143.
"Sumatra", 65.
Sumatra, 46, 108, 154, 157.
Sunda, Straits of, 14, 45.
Sweden, 73.

Tahiti, 156.
Talbot, 81, 90, 112.
Tariff, United States on China goods, 78, 79.
Tea, 13, 27, 29, 53, 76-79.
Terranova Affair, 54, 60-63, 111, 127, 143, 151, 181.
Thirteen Factory Street, 25.
"Thomas Perkins", 112.
Thompson, Captain, 18.
Thompson of Philadelphia, 63.
Thompson, Edward K., 67.
"Three Sisters", 155.
Tien Tsin, 138.
Tin, 73.
Tomlin, 105.
Tongku, 114.
"Tonquin", 42, 43, 44, 45, 164.
"Topaz", 50, 51.
Tortoise shell, 43, 58.
Townsend, Ebenezer, Jr., 39, 173.
Tracy, Ira, 93, 104, 105.
Tracy, Stephen, 105.
Travelli, J. H., 105.
Truxton, Captain, 18.
Tucker, 57.
Tuyl, Baron de, 56.
Tyler, President, 129, 130, 133, 134, 135, 140.

"Union", 44.
United States, first ship from to China, 13.
United States, growing knowledge of China, 122-127.
United States, interest of government in China, 83.
Upshur, 135.

VanBuren, Martin, 129.
Vancouver, 43, 174.
Vent, Samuel, 159.
"Vincennes", 83.

Wages, on ships, 47.
Waldo, C. F., 157.
Wallis Island, 162.
War, first Chinese-British, 7, 8, 22, 110-120, 124-127, 130.
War of 1812, 43, 45, 51.
War, opium. See War, first Chinese-British.
War, second Chinese-British, 8.
Warriner, Francis, 174.
Wars, Napoleonic, 28, 29.
"Washington", 33.
Webb, Benjamin, 155.
Webster, Daniel, 129, 130-133, 135.

Webster, Fletcher, 134, 139.
Wesleyan University, 96.
West, Thomas, 156.
West Indies and West Indian trade, 11, 12, 17, 29, 71.
Wetmore, 113.
Wetmore and Company, 82.
Whampoa, 14, 22, 24, 49, 51, 52, 88, 91, 110, 117, 137.
Whanghia, treaty of, 8, 139-144, 152-154, 192.
Wharton, Charles, 69.
Wheatland, Richard, 157, 158.
Wilcocks, 61.
Wilkes, Charles, 84, 163, 174.
"William", 159.
"William and Henry", 22, 159.
Williams, C. H., 159.
Williams, F. W., 145.
Williams, George W., 159.
Williams, S. W., 93, 98, 104, 105, 115, 175, 199.
Winn, John D., 156.
Winn, Joseph, Jr., 156.
Winship, Jonathan, 44.
Winsor, Thomas, 95.
Wolcott. See Oliver Wolcott and Company.
Wood, 82.
Wood, G. W., 105.
Woods, Leonard, 179.
Woodward, David, 175.
Wyer, Obed, 156.

Yale, 92, 101.
Yedo Bay, 98.
Yih Shan, 116.

For particulars regarding the previous Transactions of the Connecticut Academy,

Address the Librarian,
Andrew Keogh, Yale Station,
New Haven, Conn., U. S. A.

CONTENTS OF VOLUME 20 OF THE TRANSACTIONS

PAGES		PRICE
1–131	The Materials for the History of Dor, by George Dahl (May, 1915)	$1.40
133–144	New Spiders from New England, XI, by J. H. Emerton	.15
145–160	Canadian Spiders, II, by J. H. Emerton	.15
161–240	The Historical Background of Chaucer's Knight, by Professor Albert S. Cook (Feb. 1916)	1.00
241–399	Rural Economy in New England at the Beginning of the Nineteenth Century, by Percy W. Bidwell (April, 1916)	2.00

CONTENTS OF VOLUME 21 OF THE TRANSACTIONS

PAGES		PRICE
1–144	The Last Months of Chaucer's Earliest Patron, by Professor Albert S. Cook (Dec. 1916)	$1.60
145–200	The Relationship of the Tetracoralla to the Hexacoralla, by W. I. Robinson (Feb. 1917)	.40
201–313	The American Species of Marchantia, by Alexander W. Evans (March, 1917)	1.20
315–442	A Survey of Ancient Peruvian Art, by Philip Ainsworth Means (May, 1917)	1.50

CONTENTS OF VOLUME 22 OF THE TRANSACTIONS

PAGES		PRICE
1–209	The History of Early Relations between the United States and China, 1784-1844, by Kenneth Scott Latourette (Aug. 1917)	$2.20

4370 OCT 25 1917

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 22, PAGES 211-248 OCTOBER, 1917

Studies in the Calcite Group

BY

WILLIAM E. FORD

YALE UNIVERSITY PRESS

NEW HAVEN, CONNECTICUT

1917

OCT 25 1917

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 22, PAGES 211-248 OCTOBER, 1917

Studies in the Calcite Group

BY

WILLIAM E. FORD

YALE UNIVERSITY PRESS

NEW HAVEN, CONNECTICUT

1917

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

Part I. Relations existing between the chemical composition and specific gravity of Calcite, Rhodochrosite, Siderite and Magnesite

The writer has for some time been studying the data concerning the relations existing between the chemical composition and the physical properties, particularly the specific gravity and refractive indices, of the members of the Calcite Group. He has collected all readily available analyses of the minerals of the group and has in addition made or had made in the Mineralogical Laboratory of the Sheffield Scientific School a number of new analyses and physical determinations. From this study have come some interesting results which will be presented in this paper. Because of the few analyses that have been made of smithsonite and the generally unsatisfactory character of the material available for investigation it has been necessary to omit this member of the group from the present study.

Our knowledge of the molecular structure of minerals has been largely increased in recent years by the brilliant investigations made by W. H. and W. L. Bragg with the use of the X-rays. The minerals of the Calcite Group were among those studied in this way, with the result that we now have a theory as to their structure that quite completely satisfies the observed facts.[1] A description of these methods of investigation cannot very well be given here and the interested reader is therefore referred to the original articles. It is sufficient at present to say that by means of X-rays these investigators have been able to measure the distances existing between the different molecular layers in directions perpendicular to various crystal planes. In the case of calcite their measurements included the spacing parallel to the following faces, $c(0001)$, $r(10\bar{1}1)$, $e(01\bar{1}2)$, $m(10\bar{1}0)$, and $a(11\bar{2}0)$. For the other members of the group measurements are given only for the direction normal to the base, (0001). From their results they have been able to show quite conclusively that the unit cell of the crystal net-work has the shape of the

[1] See, W. L. Bragg, Proc. Roy. Soc., **80**, Series A, 485, 1913, and W. H. Bragg and W. L. Bragg, X-Rays and Crystal Structure, 112, 1915.

cleavage rhombohedron of the mineral and that the carbon and metallic atoms have the arrangement shown in FIG. 1. They have further been able to show the probable position of the oxygen atoms, but for the sake of simplicity these are not shown in the figure.

Knowing the distance between the molecular layers and the angles of the rhombohedral unit cell it is possible to calculate its volume. W. L. Bragg has found this for calcite to be 31.25×10^{-24} cc. The specific gravity of pure calcite has been very accurately determined as 2.715. Multiplying the volume of the unit cell by the specific gravity will give the mass contained in the cell. This equals 85.0×10^{-24} g. The mass of a molecule of $CaCO_3$ is given by multiplying the molecular weight by the weight of an atom of hydrogen as below,

$$100.1 \times 1.64 \times 10^{-24} = 164.0 \times 10^{-24}\ \text{g}.$$

From these two expressions it is evident that it takes two of the unit cells to contain one molecule of $CaCO_3$. Eight unit cells will, therefore, contain four molecules of $CaCO_3$. This is the

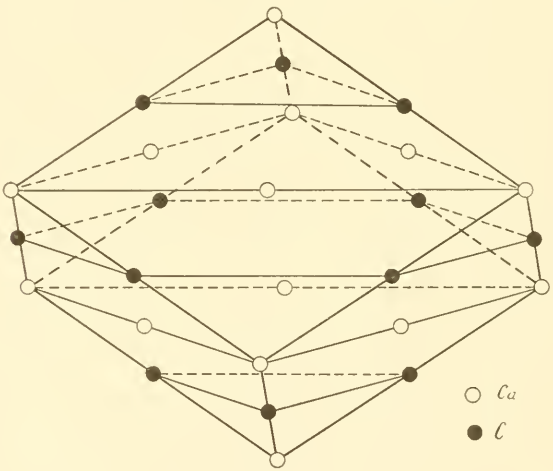


FIG. 1.

case illustrated in FIG. 1. It must be remembered in this connection that the eight atoms of calcium placed at the corners of the rhombohedron are each at the corners of eight similar figures

that meet at that point and consequently only one eight of each belongs to this particular unit. In the same way the six atoms lying in the middle of the faces of the rhombohedron belong to two adjacent units and therefore only one half of each goes with this cell. From this is is seen that only four calcium atoms with their attendant carbon and oxygen atoms belong to this volume.

The measurements given in the case of dolomite, siderite and rhodochrosite show that their molecular arrangement is of the same sort as with calcite. No measurements are given for magnesite, probably because of the difficulty of securing suitable specimens of that mineral. There can be no doubt, however, but that its structure is similar to that of the other members of the group.

Consequently, if we have given the specific gravities for the different members of this group, it is possible to calculate the volumes of the unit cells of their crystal lattices. The different specific gravities were taken as follows: calcite 2.715, dolomite 2.87, magnesite 2.96, rhodochrosite 3.70 and siderite 3.89. In the case of calcite the specific gravity was obtained from measurements on Iceland spar which is practically pure $CaCO_3$. In the case of the other members of the group, which do not occur in such pure form, the numbers were derived from a study of the different analyses of the minerals with which specific gravity determinations were given. As will be shown later, these figures have been proven to be at least very closely correct. The cell selected for the calculation was the same as that shown in FIG. 1, or eight times the volume of the unit cell. The formula used in the calculation was $\frac{1.64 \times 10^{-24} \times \text{mol. wt.}}{\text{sp. g.}} \times 4 = \text{vol.}$ The results are given in the table below. In the first column are given the actual volumes obtained, while in the second column, for the sake of greater ease in comparison, the volume of the calcite cell is reduced to 100 and the volumes of the other cells are expressed on the same scale. Of course the molecular volumes for the different minerals, obtained in the usual way by dividing the molecular weight by specific gravity, would have given results proportionate to these. It seemed interesting, however, to give the actual figures for a definite cell of the crystal lattice.

	I	II	Difference
Calcite	241.8×10^{-24}cc.	100	12.8
Dolomite	210.8×10^{-24}cc.	87.2	2.9
Rhodochrosite	203.9×10^{-24}cc.	84.3	3.5
Siderite	195.4×10^{-24}cc.	80.8	3.6
Magnesite	186.9×10^{-24}cc.	77.2	

The interesting feature in this comparison of molecular volumes is the fact that calcite stands at the head of the list with quite a large difference between its volume and that of dolomite which comes next in order. On the other hand the volumes of the other four are fairly close together. As shown in the column of the above table headed "Difference" the differences in the volumes of dolomite and rhodochrosite, of rhodochrosite and siderite and of siderite and magnesite are practically identical.

As the space lattice of a crystal depends not only on the volume of its individual cell but also upon the angles that the bounding planes of this cell make with each other, the following comparison is of interest:—

	r	r'	Plane angle of rhombic face
Calcite	74°	55′	101° 55′
Dolomite	73	45	102 38
Rhodochrosite	73	0	103 4
Siderite	73	0	103 4
Magnesite	72	36	103 18

Again we see emphasized that the space lattice of calcite is distinctly different from that of the other four members of the group.

When another molecule enters a compound in isomorphous replacement it seems certain that either one of two things must happen. Either the molecule that enters must conform to the crystal lattice of the mineral or the lattice must progressively change with the change in composition. In the first case a variation in composition would produce no corresponding change in crystal angles or molecular volume while in the second case some such change would take place. A study of the cleavage angles of the different minerals of the Calcite Group shows no evidence of any variation accompanying changes in their compositions. The largest amount of data is available with dolomite. The literature

contains some twenty-nine measurements that are given with analyses of the mineral. The average of these angles is 73° 45′. The average variation from this angle is less than 4′ while the greatest difference recorded was 23′. With the other members of the group the number of recorded angles of analyzed material is much smaller. The writer has been able to supplement these in some case by measurements on material previously analyzed. There are seven available measurements of the cleavage angle on calcite which yield an average of 74° 56′. The average variation from this angle is 15′. The greatest variation is equal to 32′ and this happens in the case of a specimen that does show considerable amounts of other molecules present. The significance of this, if there is any, is not readily seen however. The variations in the angles are larger than perhaps would be expected but they are irregular in character. If the variation was due to a definite cause, such as a change in composition, it ought to be in one direction only and, presumably in the present instance, in the direction of the smaller angles, since the cleavage angle of calcite is the largest of the group. In the case of rhodochrosite the average of four angles was 72° 53′, the average variation was 16′ and the greatest 23′. With siderite only five angles were available. Their average was 73° 3′, the average variation 8′ and the maximum difference 14′. With magnesite the average of six measurements was 72° 42′. The average departure from this angle was 9′ and the greatest 28′.

The above data are not as extensive as could be desired nor as carefully controlled. Still, the recorded variations in the cleavage angles are in most cases within the limits of natural errors of observation. While perhaps it cannot be positively stated that no variation in crystal angles takes place in the members of the Calcite Group with changes in composition it is certain that any such variation must be small. For the purposes of the present study any possible small variation must be disregarded and the angles considered as constant in their values. In other words, then, the crystal lattice of calcite, and likewise that of the other members of the group, remains the same as far as its arrangement and angles are concerned in spite of any isomorphous replacement that may occur. The only other variation possible would be in the spacing of the molecular layers which would of course still involve a change in the volume of the unit cells.

In studying the analyses of these minerals that the writer has collected, it is quite evident that there are certain definite restrictions to the amounts that the various molecules may replace each other in the different minerals. Complete isomorphous replacement in all proportions would only be expected in the case of two molecules having naturally identical space lattices or with lattices that may change progressively from one end of the series to the other. In other instances the amount of replacement would be conditional upon the similarity between the two lattices and would proportionately diminish in amount as this similarity decreased. The restrictions noted in the analyses clearly conform to the demands of this theory.

All of the analyses studied have been recalculated into percentages of the various carbonate groups and then reduced to a 100 per cent summation. Where close accuracy seemed unnecessary much of the calculating was done by means of graphical methods, which, however, are accurate certainly within two tenths of one per cent. In all the analyses which are quoted in the tables given below the results were obtained by complete arithmetical calculations. In the case of calcite the study of the molecular volumes and angles given above would lead one to expect that only comparatively small amounts of the other molecules would be found replacing the $CaCO_3$. Further, of the various possible groups, $MnCO_3$ would occur in largest amount, $FeCO_3$ next and $MgCO_3$ in smallest amount, this being the order in which their space lattices progressively differ from that of calcite.

In the analyses which have been collected there were some twenty-nine analyses of calcite that showed isomorphous replacements. All of these as far as a critical study was possible seemed trustworthy analyses. A few others were rejected from consideration because they showed distinct evidence of inaccuracies in the analysis or of impurities in the material analyzed. The average percentage of all the other carbonate molecules present in these analyses was 5.2. In only six cases did this percentage become equal to or greater than 10 per cent, the highest of all being 15.06 per cent. In twelve cases this percentage was five per cent or above. The rhodochrosite molecule, $MnCO_3$, was present in eleven cases, usually in quite small amounts but in three instances gave percentages of 11.2, 11.4 and

13.7 respectively. The siderite molecule, $FeCO_3$, was present in twenty-one analyses, its three highest percentages being 5.93, 6.0 and 7.3. The magnesite molecule, $MgCO_3$, was present in twenty analyses; in only three cases, however, did its percentage rise above three per cent, namely 3.0, 3.8 and 7.4.

Since dolomite is in many ways distinct from the other members of the group and needs a rather more extended consideration, the description of its characters will be postponed for the present and will be given in detail further on. The other members of the group can be discussed now.

The siderite and magnesite molecules may mix together in all proportions and the same is apparently true of the siderite and rhodochrosite molecules. These facts are shown graphically in Fig. 2. Points along the vertical lines represent percentages of $MgCO_3$, $FeCO_3$ and $MnCO_3$ respectively. The cross lines represent different analyses of these minerals which give the percentages shown at the ends of the lines. The horizontal lines represent those analyses that contained only the two different molecules, while the slanting lines belong to those that showed more than two isomorphous constituents. For the sake of clearness a few lines have been omitted in the most congested portions of the figure.

It is clearly seen that the $FeCO_3$-$MgCO_3$ series is practically complete, such gaps as do exist being small and probably accidental. In the case of the $FeCO_3$-$MnCO_3$ series there is one considerable break between 30-50 per cent $FeCO_3$ and 50-70 per cent $MnCO_3$. It is difficult to say at present whether this break has any real significance or is again accidental.

If we consider as rhodochrosite all those analyses that show more than 50 per cent of $MnCO_3$ we can study the amounts of the $CaCO_3$ and $MgCO_3$ molecules that may occur in it. We have some twenty-three such analyses for examination. The calcium carbonate molecule occurs in twenty-one of these analyses with an average percentage of 4.9. More than half of the analyses show percentages considerably below this average while in only three cases does the percentage rise above 10 per cent, namely, 10.4, 10.5 and 13.1. Eleven of these analyses showed the presence of $MgCO_3$ with an average of 2.7 per cent. In only one case, 7.2 per cent, did the amount present exceed five per cent. Arguing from the analytical data at hand it would

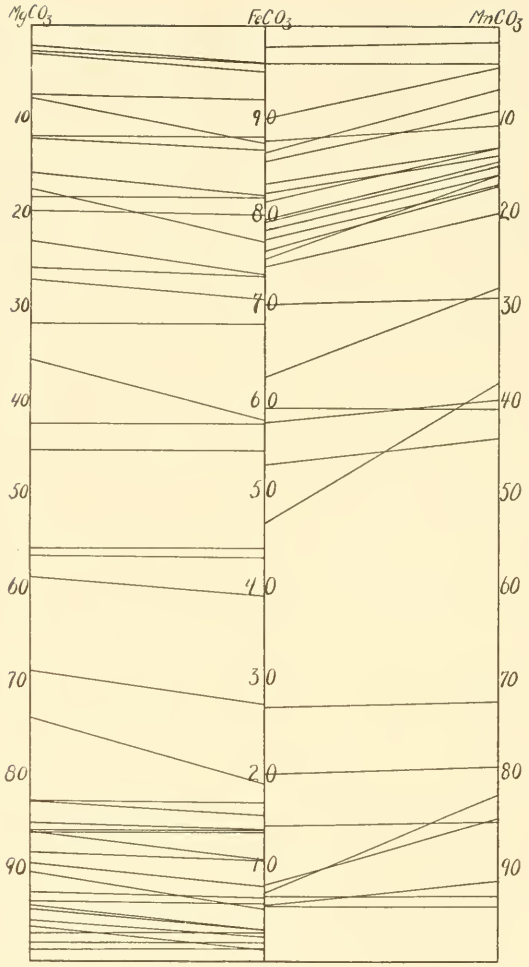


FIG. 2.

therefore seem, as if, next to $FeCO_3$ the $CaCO_3$ group could enter the rhodochrosite molecule with the greatest and the $MgCO_3$ molecule with the least freedom. This is a conclusion contrary to what would have been expected from a consideration of the molecular volumes of the different groups. The fact, however, that $MgCO_3$ occurs comparatively seldom in the analyses may indicate that the conditions for formation of rhodochrosite are unfavorable to its presence. It might be that the

small amount of $MgCO_3$ observed in the mineral is due rather to this than to its inability to replace $MnCO_3$ in the molecular structure. It should also be stated that the four analyses showing the highest percentages of $CaCO_3$ are all old analyses and that there is no way of testing their accuracy. Between the one of these showing the lowest percentage of $CaCO_3$ (9.0) there is a jump of more than three per cent to the next percentage (5.9). If these four analyses could be eliminated it would bring the facts much nearer what would seem to be the logical theory. It should also be stated that there is one exceptional analysis of rhodochrosite recorded that has not been included in the above list. The mineral came from Franklin, N. J., and showed, $ZnCO_3$ 2.28, $FeCO_3$ 0.35, $MgCO_3$ 3.74, and $CaCO_3$ 20.37.[2] This is clearly a very unusual case. Other analyses that are quoted sometimes under rhodochrosite and show large amounts of calcium carbonate are probably to be considered as manganiferous dolomites.

In the case of siderite we have some fifty analyses that show more than 50 per cent of $FeCO_3$. As already indicated both $MgCO_3$ and $MnCO_3$ occur in isomorphous mixtures with $FeCO_3$ in practically all proportions. Twenty-four of the analyses show also the presence of $CaCO_3$. In all cases, except five, this occurs in amounts less than 2 per cent. In these exceptional cases the percentages are 3.1, 3.2, 7.0, 10.0 and 11.9. It would seem as if there was justification in rejecting the last three values since none of the specimens appears to have been crystalline, two of them being of the variety known as sphærosiderite. Without including these the average content of $CaCO_3$ becomes 1.0 per cent.

There were fifty analyses of magnesite that showed over 50 per cent of $MgCO_3$. One half of these showed the presence of $CaCO_3$ with an average amount of 2.5 per cent. Eleven of the analyses showed less than 2 per cent $CaCO_3$ and in only two cases did this rise above 4 per cent, namely 6.9 and 9.7. There is one analysis of magnesite quoted with some 23 per cent of calcium carbonate. This, in view of the above facts, was rejected as an extremely doubtful case. Thirteen of these analyses showed the presence of $MnCO_3$, which with one exception occurred in percentages less than 3.5. The exception showed 13.3 per cent

[2] Browning, Am. J. Sc., **40**, 375, 1890.

$MnCO_3$. Here, similar to the case of rhodochrosite it is apparently the conditions under which magnesite commonly occurs that limits the amount of the $MnCO_3$ present, rather than the difference in molecular structure.

From the above it is seen that the theoretical assumptions as to the miscibility of the different molecules with each other are well substantiated by the study of actual analyses. Therefore, it seems clear that we can say of calcite, rhodochrosite, siderite and magnesite that each has an individual space lattice and the entrance of the other molecules into the composition of anyone of these is conditioned upon the amount that can be present and still adapt itself to the structure of the mineral. The only way apparently in which the space lattice of calcite could vary would be in the spacing of the molecular layers. It might be possible that the introduction into the mineral of other molecules with different molecular spacings would proportionately modify the calcite structure. Such a change would involve a change in molecular volumes and would presumably make possible a complete isomorphous series. It is of interest to examine analyses of calcite to see if the introduction of other molecules does appreciably modify the molecular volumes. In TABLE I are given some fourteen analyses which, it should be stated, include all the available analyses with which specific gravities have been given. There are no omissions from the list except in cases where the analysis clearly showed some error or impurity.

TABLE I

CALCITE ANALYSIS

	$CaCO_3$	$MgCO_3$	$MnCO_3$	$FeCO_3$	Locality	Ref.*
1	99.34	0.44	0.22		Joplin	1
2	98.86	1.03	0.11		?	1
3	98.80	1.02	0.18		Joplin	1
4	98.71	0.87	0.42		Niagara	1
5	97.15	1.56		1.29	Salzburg	2
6	96.29	0.80		2.91	Ouray	1
7	95.05	1.87		3.08	Kolozruky	3
8	94.81	1.74		3.45	"	3

* (1) Foote and Bradley, Am. J. Sc., 37, 342, 1914. (2) Eisenhuth, Zs. Kr., 35, 601, 584, 1901. (3) Erben, *ref.*, Zs. Kr., 12, 664, 1887. (4) Jentsch, Pogg. Ann., 96, 145, 1855. (5) Bukousky, *ref.*, Zs. Kr., 39, 400, 1904. (6) Weibull, *ref.*, Zs. Kr., 10, 512, 1885.

	$CaCO_3$	$MgCO_3$	$MnCO_3$	$FeCO_3$	Locality	Ref.*
9	94.48	3.01		2.51	Zillertal	2
10	93.16	1.09	5.75		Guanajuato	1
11	86.68	7.36		5.96	Kolozruky	3
12	86.46	1.92	11.02	0.60	New Jersey	4
13	84.94	0.45	13.75	0.86	Kuttenberg	5
14	83.26	0.45	11.40	4.89	Vester-Silfberg	6

	Molecular Volumes			Specific Gravities		
	Meas.	Calc.	Diff.	Meas.	Calc.	Diff.
1	99.6	99.9	+0.3	2.724†	2.714	—.010
2	99.8	99.7	—0.1	2.717†	2.711	—.006
3	99.7	99.7	0.0	2.720†	2.712	—.008
4	100.5	99.7	—0.8	2.699†	2.713	+.014
5	99.8	99.4	—0.4	2.720	2.714	—.006
6	99.3	99.2	—0.1	2.744†	2.723	—.021
7	99.7	99.0	—0.7	2.728	2.720	—.008
8	99.6	98.9	—0.7	2.732	2.723	—.009
9	99.0	98.8	—0.2	2.740	2.713	—.027
10	99.2	98.8	—0.4	2.755†	2.734	—.021
11	98.3	97.2	—1.1	2.756	2.709	—.047
12	98.7	97.2	—1.5	2.788	2.754	—.034
13	99.9	97.5	—2.4	2.755	2.773	—.002
14	99.2	97.1	—2.1	2.804	2.781	—.023

In the second half of the table two molecular volumes are given for each analysis. In the column headed *"Meas.,"* the volume has been derived from the percentage composition and the measured specific gravity. In the column headed *"Calc.,"* the number has been obtained by multiplying the molecular volume of each molecule, as given in the table on page 216, by its corresponding percentage and dividing the sum of these by 100. For the sake of ease in comparison the molecular volume of pure calcite has been assumed to be 100 and the volumes of the various specimens analyzed have been calculated on that scale. It will be noted that the "measured" molecular volumes of the different calcites remain nearly constant, the average departure from the theoretical value of 100 being 0.56. Although the latter analyses in the list show somewhat greater divergencies than those given first, the variation is not great and does not seem to be at all regular. If each molecule retained its own structure and molecular volume when it entered into isomorphous replacement, or, what would practically amount to the same thing, if its

† Determinations made by the writer.

entrance would proportionally affect the structure of the whole mineral, we should have the molecular volumes that are given in the column headed *"Calc."* It will be seen that the values in this second column show a steady decline as the percentages of $CaCO_3$ decrease and in general increasing differences from the values derived from the measured specific gravities. Therefore we can safely say that the molecular structure of calcite shows little or no change with variation in composition and that for practical purposes its space lattice can be considered as constant in all particulars.

This conclusion has an important bearing on the study of the connection existing between the variation in specific gravity and variation in composition. We must recognize that the different molecules as they enter calcite must have specific gravities that correspond to its particular space lattice and which are different from the specific gravities they would have as separate species. For instance any $FeCO_3$ entering into the calcite structure will occupy a larger volume and therefore have a lower specific gravity than when it occurs in the more constricted lattice of siderite. Having given, therefore, the specific gravity of pure $CaCO_3$, it is possible to calculate what the specific gravities of the isomorphous molecules must be when they occupy its particular crystal lattice. The following equation expresses these relations, $\frac{\text{Molecular Weight}}{\text{Specific Gravity}} = K$, where K is a constant corresponding to the molecular volume. In the case of calcite this becomes $\frac{100.1}{2.715} = K$, or $K = 36.86$. To find, therefore, the specific gravity of $FeCO_3$ when occupying the calcite lattice we use the following expression, $\frac{115.9}{36.86} = \text{Sp. G.}$, from which the value of 3.148 is obtained. In this way the specific gravities for the different molecules as they enter calcite have been calculated and are given below:

	$CaCO_3$	$MgCO_3$	$MnCO_3$	$FeCO_3$
In calcite	2.715	2.288	3.123	3.148

Using these figures the theoretical specific gravities have been calculated for the calcite analyses and are given together with the measured values in the second half of the above table. The

average difference between the measured and calculated values is .017, which is within the limit of error of the ordinary specific gravity determination. An interesting and possibly significant fact is that the great majority of the differences between the measured and calculated values are negative in character. This was true also, of course, in the case of the molecular volumes. This would be explained if the value assigned to the specific gravity of calcite was too low. In fact, if the specific gravity of calcite had been taken as 2.72, the average difference, taking in this case the plus and minus signs into consideration, would have been —.008.

In the case of the magnesite-siderite series, since their molecular volumes and crystal angles are very closely the same, it follows that their crystal lattices are practically identical and we should expect a continuous isomorphous series between them. This, for the same reason, would also be the case with the siderite-rhodochrosite series. It has already been shown that these two series do show such isomorphism.

Below is given in tabular form the available analyses of these two series with which the specific gravities are recorded. Numbers proportionate to the molecular volumes of each specimen as derived from the percentages of the different molecules present and the specific gravity are also given. It will be noted that these values show a small but fairly regular progressive change from the magnesite end to the siderite end of the first series and from the siderite end to the rhodochrosite end of the second series. It is evident, therefore, in these series, that either, since the molecular structures of the chief components are so closely similar, they may crystallize together and still each preserve its individuality, or that the molecular structure of the combination can adjust itself in accordance with the amounts of the different constituents present. Whichever case is true, it ought to be possible to calculate the molecular volume and specific gravity of each specimen directly from the percentage composition.

In the case of the $CaCO_3$ molecule, however, it would appear logical to consider that since its lattice in calcite is distinctly different from the lattice of rhodochrosite, siderite and magnesite, its structure when it occurs in these minerals, would have to be modified to conform to their network. Since, however, the

$CaCO_3$ molecule is never present in these minerals in large amount, no appreciable error will be introduced into the calculations if we take it as having the same specific gravity and molecular volume as in calcite. Using therefore the specific gravities for the different molecules as given on p. 215 the theoretical specific gravities have been calculated for each analysis. These together with the measured values are given in the second half of TABLE II. Without making any attempt to critically examine the analyses the average difference between the calculated and measured specific gravities is .048, or if the plus and minus signs are considered it becomes +.008. It seems

TABLE II

MAGNESITE-SIDERITE AND SIDERITE-RHODOCHROSITE SERIES

Anal.	$CaCO_3$	$MgCO_3$	$MnCO_3$	$FeCO_3$	Locality	Ref.*
1		98.75		1.25	Snarum	1
2		98.58		1.42	"	2
3		97.74		2.26	"	1
4		96.30		3.70	Zwickau	3
5	2.36	94.19		3.45	Sunk	4
6		92.36	0.79	6.85	Unst	5
7	3.35	91.50		5.15	Veitsch	6
8		86.00		14.00	Miask	7
9	2.15	83.55		14.30	Greiner	8
10	2.75	82.39		14.86	Zillertal	8
11	2.16	82.37		15.47	Pfitschtal	8
12	1.33	68.35	13.33	16.99	Greiner	8
13	2.31	58.74		38.95	Traversella	9
14		55.91		44.09	Salzburg	10
15		49.84		50.16	Traversella	6
16	3.25	35.73	3.24	57.78	Saarbrücken	11
17	1.31	23.29	2.16	73.24	Allevard	6

* (1) Marchand and Scheerer, J. prakt. Chem., **50**, 95. (2) Münster, Pogg. Ann., **65**, 292, 1845. (3) Jentsch, N. Jb. Min., 535, 1853. (4) Rumpf, Min. Mitt., 263, 1873. (5) Heddle, Min. of Scotland, 1, 140. (6) Bradley, previously unpublished. (7) Nikolajev, Min. Russlands, **7**, 222, 1875. (8) Eisenhuth, Zs. Kr., **35**, 594, 595, 599, 1901. (9) Fritsche, Pogg. Ann., 70, 147, 1847. (10) Patera, Haidinger Ber., **2**, 296, 1847. (11) Weiss, J. preuss. geol. L. A., 113, 1885. (12) Manasse, Att. Soc. Tosc., **22**, 81, 1906. (13) Ford, previously unpublished. (14) Manasse, Proc. Verb. Sc. Nat. Tosc., **15**, 20, 1906. (15) Khuen, Handbuch Min. Chem., 1, 420. (16) Hutchinson, Min. Mag., **13**, 209, 1903. (17) Dürr, Zs. Kr., **47**, 304, 1909. (18) Penfield, Am. J. Sc., **18**, 50, 1879. (19) Sandberger, N. Jb. Min., **2**, 37, 1892. (20) Kunz, Am. J. Sc., **34**, 477, 1887.

Anal.	$CaCO_3$	$MgCO_3$	$MnCO_3$	$FeCO_3$	Locality	Ref.*
18		25.43		74.57	Toscana	12
19	0.63	17.86	4.66	76.85	Bend	13
20		19.94		80.06	Bottino	14
21		18.59		81.41	"	14
22		15.93	2.60	81.47	Mitterberg	15
23	1.56	9.13	5.69	83.62	Roxbury	13
24		12.27		87.73	Toscana	12
25	0.18	0.26	1.82	97.74	Cornwall	16
26			4.11	95.89	Greenland	13
27	4.14	5.26	13.00	77.60	Markirk	17
28	0.37	6.56	15.84	77.23	Neudorf	13
29	0.60		72.34	27.06	Branchville	18
30	0.82		79.29	19.89	"	6
31	0.54		85.12	14.34	Arzberg	19
32			94.21	5.79	Alicante	20

	Molecular Volumes			Specific Gravities		
Anal.	Meas.	Calc.	Diff.	Meas.	Calc.	Diff.
$MgCO_3$		77.2			2.96	
1	75.9	77.2	+1.3	3.017	2.972	—.045
2	74.8	77.2	+2.4	3.065	2.973	—.092
3	76.5	77.3	+0.8	3.017	2.981	—.036
4	75.4	77.5	+2.1	3.067	2.994	—.082
5	78.1	77.9	—0.2	2.98	2.986	+.006
6	76.1	77.5	+1.4	3.093	3.029	—.064
7	77.4	78.1	+0.7	3.029†	3.000	—.029
8	77.6	77.7	+0.1	3.10	3.090	—.010
9	78.5	78.2	—0.3	3.08	3.087	+.007
10	78.5	78.4	—0.1	3.09	3.091	+.001
11	79.3	78.2	—1.1	3.06	3.098	+.038
12	81.6	79.1	—2.5	3.115	3.213	+.098
13	78.5	79.1	+0.6	3.35	3.318	—.032
14	79.7	78.8	—0.9	3.33	3.370	+.040
15	80.4	79.0	—1.4	3.374†	3.426	+.052
16	81.9	80.2	—1.7	3.442	3.513	+.071
17	80.8	80.3	—0.5	3.633†	3.644	+.011
18	83.1	79.9	—3.2	3.52	3.653	+.133
19	80.7	80.4	—0.3	3.707†	3.707	.000
20	79.5	80.1	+0.6	3.74	3.705	—.035
21	79.6	80.2	+0.6	3.75	3.717	—.033
22	80.5	80.3	—0.2	3.735	3.737	+.002
23	80.7	80.9	+0.2	3.793†	3.776	—.017
24	81.9	80.3	—1.6	3.71	3.776	+.066
25	79.9	80.9	+1.0	3.936	3.882	—.054

† Determinations made by the author.

	Molecular Volumes			Specific Gravities		
Anal.	Meas.	Calc.	Diff.	Meas.	Calc.	Diff.
$FeCO_3$		80.8			3.89	
26	79.6	80.9	+1.3	3.951†	3.882	—.069
27	86.6	81.9	—4.7	3.55	3.768	+.218
28	80.9	81.2	+0.3	3.813†	3.794	—.019
29	83.1	83.4	+0.3	3.76	3.745	—.015
30	83.4	83.7	+0.3	3.743†	3.730	—.013
31	86.8	83.9	—2.9	3.59	3.722	+.132
32	84.5	84.1	—0.4	3.69	3.711	+.021
$MnCO_3$		84.3			3.70	

legitimate, however, to eliminate certain analyses from consideration. The specific gravities of Anal. 18, *27* and 31 for instance, when compared with those of other similar analyses are obviously too low. These are the most striking cases and there are others which might well be considered also. Omitting, however, only these three, the average difference between the measured and calculated values becomes .034 or if the signs are used, —.005. There seems no doubt, therefore, but that the figures chosen to represent the specific gravities of the different molecules are correctly chosen and that it is quite possible to calculate the specific gravities of these minerals directly from their percentage composition.

Part II. Relations Existing Between the Chemical Composition and Specific Gravity of Dolomite

Dolomite, for a long time, was considered as an isomorphous mixture of the calcite and magnesite molecules in approximately equal proportions. For various reasons this has been shown not to be the case. For instance, the series $CaCO_3$-$MgCO_3$ is far from complete. We have calcite containing small amounts of magnesium carbonate and magnesite containing likewise small amounts of calcium carbonate but large breaks in the series exist on both sides of the dolomite mixture. Further, as shown by Rettgers[1] the specific gravity of dolomite falls distinctly below the theoretical value for an isomorphous mixture of the calcite and magnesite molecules. Lastly the fact, that dolomite has been shown to have tetartohedral symmetry, gives another proof that it is a distinct and individual compound. Yet its similarity in crystalline and optical characters to the other members of the Calcite Group shows that it has close structural relations with them.

W. L. Bragg[2] has shown by means of the X-ray that the internal structure of dolomite is similar to that of the other members of the group. He makes the suggestion that the arrangement of the molecular planes perpendicular to the vertical crystal axis is like that of calcite, see Fig. 1, with however, the planes that contain the metallic atoms showing alternately calcium and magnesium. This arrangement would serve to explain the tetartohedral symmetry of the mineral. Bragg adds, however, that as yet the X-ray has not given any evidence to prove the truth of this assumption.

Normal dolomite has the composition of $CaMg(CO_3)_2$ into which ferrous iron commonly enters and less frequently manganese. These last seem always to replace the magnesium in the molecule and never the calcium. Lately it has been recognized that $CaCO_3$ may also occur as an isomorphous constituent and some analyses would suggest that under rarer conditions $MgCO_3$ might enter the molecule as well. The various isomorphous

[1] Zs. Phys. Chem., **6**, 227, 1890.

[2] Proc. Roy. Soc., **89**, 488, 1913.

groups therefore, that may make up the composition of the mineral can be written as $CaMg(CO_3)_2$, $CaFe(CO_3)_2$, $CaMn(CO_3)_2$, $CaCa(CO_3)_2$ and possibly $MgMg(CO_3)_2$. The molecules $CaMg(CO_3)_2$ and $CaFe(CO_3)_2$ must be considered to form a true isomorphous series since they can apparently replace each other in any proportion. It is true that the end of the series toward $CaFe(CO_3)_2$ has not been observed among minerals, but that is probably due to lack of favorable conditions of formation rather than to the impossibility of its occurrence. Foote and Bradley[3] have recently investigated the question as to the amount of excess $CaCO_3$ that dolomite may contain. They analyzed dolomites that had been crystallized upon calcite and that, therefore, must have been formed from solutions that were saturated with calcium carbonate. Such dolomites should carry the maximum amount of isomorphous calcium carbonate. They found that this excess amount of $CaCO_3$ could reach as high as 20 per cent. Their results have been clearly confirmed by the study of all available dolomite analyses. Over one hundred such analyses were collected and recalculated into their various isomorphous molecules. It seems unnecessary to quote these analyses in detail here, but it will be of interest to give in tabular form (TABLE III) the percentages that they show of $MgCO_3$ and $CaCO_3$ in excess of that required in the usual molecules.

TABLE III

Excess $MgCO_3$		Excess $CaCO_3$					
16.1	1.5	0.1	0.8	2.1	3.4	6.3	10.0
7.3	1.3	0.2	0.9	2.2	3.5	6.3	11.6
7.0	0.7	0.2	1.0	2.2	3.6	6.5	12.0
5.8	0.7	0.3	1.0	2.2	3.7	6.6	12.6
2.8	0.6	0.3	1.0	2.4	3.8	7.3	14.6
2.6	0.4	0.4	1.2	2.5	3.9	8.1	15.6
2.1	0.3	0.4	1.3	2.6	4.0	8.3	16.1
1.7	0.2	0.4	1.3	2.8	4.4	8.5	17.2
1.5	0.2	0.4	1.4	2.8	4.4	8.5	17.2
		0.6	1.5	2.8	4.5	8.9	17.9
		0.7	1.6	2.9	4.6	9.1	19.7
		0.8	1.7	3.1	4.7	9.2	20.9
		0.8	1.8	3.2	4.7	9.6	27.5
		0.8	2.0	3.4	5.5		

[3] Am. Jour. Sci., 37, 339, 1914.

The variation in composition shown by these analyses of dolomite is represented graphically in Fig. 3. This is a portion of the triangular projection of which $CaCO_3$, $MgCO_3$ and $(Fe,Mn)CO_3$ are the three points (see Fig. 5). Since manganese carbonate in molecular weight, etc., is practically equivalent to ferrous carbonate these two radicals have been combined

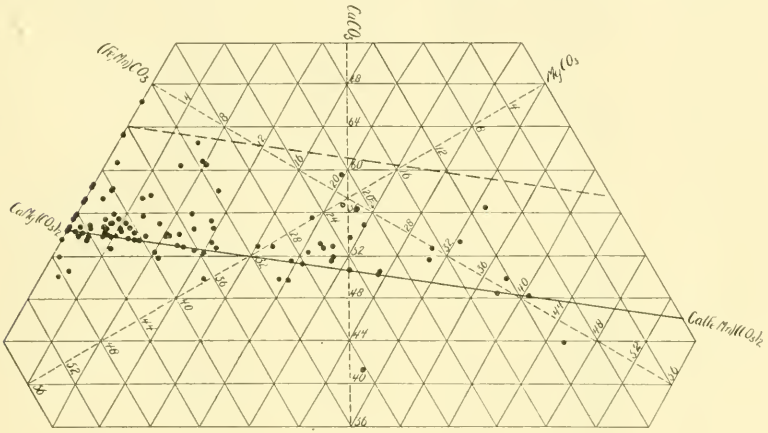


Fig. 3.

and treated as one. The heavy solid line running diagonally across the figure gives the locus of the points representing the simple mixtures of $CaMg(CO_3)_2$ and $Ca(Fe,Mn)(CO_3)_2$. The heavy broken line that lies above and parallel to this line, represents the maximum limit of the amount of $CaCO_3$ that may enter the mineral as established by Foote and Bradley. It is to be noted that while a considerable number of the analyses lie on or very close to the line, $CaMg(CO_3)_2$-$Ca(Fe,Mn)(CO_3)_2$, a large number also fall above it and therefore show the presence of isomorphous $CaCO_3$. There are a few analyses whose points fall below this line. These are the ones that show an excess of $MgCO_3$, which, as shown in Table III, in most cases is limited in amount. For the present and until more evidence is available it would seem reasonable to reject the analysis showing over 16 per cent of extra $MgCO_3$ and place the limit of this possible excess at about 7 per cent. It is possible, of course, that $MgCO_3$ does not occur in dolomite in this way and that its presence

TABLE IV

DOLOMITE ANALYSES

No.	$CaMg(CO_3)_2$	$CaFe(CO_3)_2$	$CaMn(CO_3)_2$	$MgCO_3$	$CaCO_3$	Sp. G.	Locality	Ref.*
1	99.8				0.2	2.896	Ceylon	1
2	98.3	1.5		0.2		2.81	Scotland	2
3	96.7	2.9			0.4	2.862	Jolsva	3
4	96.6				3.4	2.83	Modane	4
5	95.5	3.3			1.2	2.920	Greiner	5
6	95.0	2.5	1.7		0.8	2.872	Cambo	6
7	93.7	6.1		0.2		2.92	Greiner	5
8	93.1	4.8	1.9		0.2	2.89†	Vorderrheintal	7
9	92.9	6.2			0.9	2.89	Greiner	5
10	92.7	7.1			0.2	2.89	"	5
11	92.7	6.3			1.0	3.04	Pfitschtal	5
12	92.6	5.2			2.2	2.90	Greiner	5
13	92.4	3.5	2.4	1.7		2.865	Scotland	2
14	92.2	5.6			2.2	2.89	Greiner	5
15	92.2	5.2			2.6	2.90	"	5
16	91.8	5.0			3.2	3.10	Hall	5
17	91.1	5.8			3.1	2.90	Greiner	5
18	90.7	3.5		5.8		2.878	Lakeport	8
19	90.7	7.8			1.5	2.90	Greiner	5
20	90.2	8.5			1.3	2.94	Mte. Catini	5
21	90.2	6.2			3.6	2.90	Greiner	5
22	90.0	5.4			4.6	2.90	Pfitschtal	5
23	90.0	8.0			2.0	2.93	Greiner	5
24	89.6	8.0	1.7		0.7	2.889	Djelfa	6

* (1) Grünling, Zs. Kr., **33**, 217, 1900. (2) Heddle, Min. Mag., **2**, 109, 21, 20, 1878. (3) Loczka, Zs. Kr., **35**, 282, 1901. (4) Sella, R. Acc. Lincei, **4**, 454, 1888. (5) Eisenhuth, Zs. Kr., **35**, 584-593, 601, 603, 604, 1901. (6) Arsandaux, Bull. Soc. Min., **24**, 473, 1901. (7) Ford, previously unpublished. (8) Farrington, *ref.*, Zs. Kr., **36**, 78, 1901. (9) Foote and Bradley, Am. J. Sc., **37**, 343, 1914. (10) Erben, *ref.*, Zs. Kr., **12**, 665, 1887. (11) Dürr, *ref.*, Zs. Kr., **47**, 304, 1909. (12) Weiss, *ref.*, Zs. Kr., **13**, 51, 1887. (13) Samoilov, *ref.*, Zs. Kr., **46**, 287, 1909. (14) Lincio, Att. Acc. Torino, **46**, 969, 1911. (15) Fahrenhorst, *ref.*, Zs. Kr., **36**, 419, 1901. (16) Rogers, *ref.*, Zs. Kr., **34**, 206, 1900. (17) Bukovsky, *ref.*, Zs. Kr., **39**, 400, 1903. (18) Weibull, *ref.*, Zs. Kr., **10**, 513, 1884.

† Determinations made by the author.

No.	$CaMg(CO_3)_2$	$CaFe(CO_3)_2$	$CaMn(CO_3)_2$	$MgCO_3$	$CaCO_3$	Sp. G.	Locality	Ref.*
25	89.4	6.7			3.9	2.955	Pfitschtal	5
26	89.4	10.0			0.6	2.93	Greiner	5
27	88.0	9.5			2.5	2.92	Greiner	5
28	88.0	10.4			1.6	2.93	"	5
29	87.6	3.5			8.9	2.851†	Joplin	9
30	87.4	5.0	6.9	0.7		2.88	Greiner	5
31	86.9	3.5			9.6	2.83	Kolozruky	10
32	81.7	16.2		2.1		2.90	Greiner	5
33	79.8	17.4			2.8	2.90	"	5
34	79.7	14.5	4.3	1.5		2.91	Scotland	2
35	78.3	21.7				2.95	Traversella	5
36	76.7	7.6	11.2		4.5	2.91	Greiner	5
37	73.2	11.2			15.6	2.886†	Guanajuato	9
38	72.7	21.0			6.3	2.90	Wallis	5
39	69.3	15.6			16.1	2.905†	Guanajuato	9
40	68.6	29.0			2.4	3.04	Altwasser	5
41	67.9	11.2	3.7		17.2	2.75	Markirch	11
42	66.8	6.3	6.0		20.9	2.868†	Ouray	9
43	64.9	27.5	4.8		2.8	2.940	Saarbrücken	12
44	62.9	36.7			0.4	2.94	Nagolnij Krjasch	13
45	61.5	38.5				3.03	"	13
46	58.5	38.7			2.8	3.003	Simplon	14
47	54.6	41.9	2.5		1.0	2.96	Madgeburg	15
48	48.6	51.2		0.2		3.025	St.-Pierre-d'Allevard	6
49	46.8	51.8			1.4	2.99	Rolla	16
50	45.2	41.2	2.0		11.6	2.95	Kuttenberg	17
51	38.0	48.2	9.1		4.7	3.05	"	17
52	31.5	25.7	34.7		8.1	3.01	"	17
53	24.7	70.6	4.6		0.1	3.121†	Erzberb	7
54	8.3	12.6	71.8	7.3		3.06	Kuttenberg	17
55		21.0	75.3		3.7	3.009	Vester-Silfberg	18

shown in these cases is due to errors of analysis. There are, however, eleven analyses or about one tenth of the total number studied that show over 1 per cent of extra $MgCO_3$. Therefore, it seems most likely that magnesium carbonate may occur in this way in dolomite. The conditions necessary for its occurrence are certainly much less common than in the similar case of $CaCO_3$.

The question as to how the entrance of these various isomorphous molecules into dolomite will affect its physical characters is a very complex one. If $CaMg(CO_3)_2$ and $CaFe(CO_3)_2$ form a true isomorphous series the physical properties should vary directly with the proportion of each molecule present. The problem is rendered more complicated by the occurrence of isomorphous $CaCO_3$ and $MgCO_3$ and in a minor degree by the substitution of manganese for iron. The first relationship studied was that between the variation in the specific gravity and variation in composition.

Above, in TABLE IV, is given all the dolomite analyses with which specific gravities are recorded. These analyses have been recalculated into the various carbonate molecules and the summation then reduced to 100 per cent. The analyses are arranged according to decreasing amounts of the normal dolomite molecule, $CaMg(CO_3)_2$. A careful survey of the table shows that there must be in some cases an error present, either in the analysis itself, or in the specific gravity determination. This would naturally have been expected where all analyses are included without any possible critical study of their character. For instance, the specific gravity of analysis No. 2 is obviously too low, as is seen by comparing it with the other analyses near it in the table. In the same way the specific gravities with analyses Nos. 11, 16 and 40 are seen to be too high, while those of Nos. 41 and 55 are too low. These six analyses should certainly, therefore, not be considered in our calculations. There are others which might be included in this list but it is felt unnecessary to push this discrimination too far, since any errors introduced by them would not be large and would most probably compensate each other.

The water clear crystalline dolomite from the Binnental, Switzerland, has very closely the composition of normal dolomite, $CaMg(CO_3)_2$. Its specific gravity was determined by Rettgers as 2.87.[4] We have seen that there is no evidence of any change in the crystal angles of dolomite accompanying the change in composition. We must conclude, therefore, that the crystal lattice of dolomite remains constant in regard to its angles. If we assume that the spacing of the molecular layers in the net-

[4] Loc. cit.

work is also constant, then we should, given the specific gravity of $CaMg(CO_3)_2$, be able to calculate the specific gravities of the various molecules that may replace it. On making these calculations the following values are obtained, $CaMg(CO_3)_2$ 2.87, $CaFe(CO_3)_2$ 3.36, $CaMn(CO_3)_2$ 3.34, $MgCO_3$ 2.62, $CaCO_3$ 3.11. These values were used to calculate the specific gravities corresponding to the different analyses. The measured and calculated values together with their differences are given in the columns I, II and III of TABLE V, the numbers corresponding to the six doubtful analyses mentioned above having been omitted from the list.

TABLE V

SPECIFIC GRAVITIES

	I	II	III	IV	V
	Meas.	Calc.	Diff.	Calc.	Diff.
1	2.896	2.870	—.026	2.870	—.026
3	2.862	2.885	+.023	2.875	+.013
4	2.83	2.878	+.048	2.868	+.038
5	2.920	2.889	—.031	2.879	—.041
6	2.872	2.892	+.020	2.882	+.010
7	2.92	2.899	—.021	2.890	—.030
8	2.89	2.903	+.013	2.882	—.008
9	2.89	2.902	+.012	2.883	—.007
10	2.89	2.905	+.015	2.885	—.005
12	2.90	2.901	+.001	2.881	—.019
13	2.865	2.894	+.029	2.874	+.009
14	2.89	2.902	+.012	2.883	—.007
15	2.90	2.901	+.001	2.882	—.018
17	2.90	2.906	+.006	2.886	—.014
18	2.878	2.873	—.005	2.853	—.025
19	2.90	2.912	+.012	2.892	—.008
20	2.94	2.914	—.026	2.894	—.046
21	2.90	2.909	+.009	2.888	—.012
22	2.90	2.907	+.007	2.887	—.013
23	2.93	2.913	—.017	2.893	—.037
24	2.889	2.919	+.030	2.898	+.009
25	2.955	2.912	—.043	2.892	—.063
26	2.93	2.920	—.010	2.899	—.031
27	2.92	2.922	+.002	2.893	—.027
28	2.93	2.925	—.005	2.895	—.035
29	2.851	2.908	+.057	2.878	+.027
30	2.88	2.925	+.045	2.895	+.015
31	2.83	2.910	+.080	2.880	+.050
32	2.90	2.939	+.039	2.902	+.002

	I Meas.	II Calc.	III Diff.	IV Calc.	V Diff.
33	2.90	2.962	+.062	2.912	+.012
34	2.91	2.957	+.047	2.907	—.003
35	2.95	2.976	+.026	2.924	—.026
36	2.91	2.970	+.060	2.919	+.009
37	2.886	2.962	+.076	2.900	+.014
38	2.90	2.988	+.088	2.926	+.026
39	2.905	3.013	+.108	2.941	+.036
42	2.868	2.979	+.111	2.904	+.036
43	2.940	3.043	+.103	2.951	+.011
44	2.94	3.050	+.110	2.963	+.023
45	3.03	3.058	+.028	2.965	—.065
46	3.003	3.066	+.063	2.968	—.035
47	2.96	3.089	+.129	2.980	+.020
48	3.025	3.120	+.095	3.000	—.025
49	2.99	3.127	+.137	2.997	+.007
50	2.95	3.109	+.159	2.979	+.029
51	3.05	3.160	+.110	3.008	—.042
52	3.01	3.178	+.168	3.109	+.099
53	3.122	3.237	+.114	3.055	—.067
54	3.06	3.251	+.191	3.019	—.041

It will be noted that the agreement between the measured and calculated values is surprisingly close as far as through analysis No. 28. In these twenty-five analyses only six show a difference in these two values greater than .025 and in nine cases this difference is equal to or less than .01. The average difference for the twenty-five analyses is .017 or if the + and — signs be considered, +.002. It will be noticed that these analyses include approximately those that contain 90 per cent or more of the normal dolomite molecule. Beyond this point, however, the table shows a rapid and progressive rise in the amount of the departure of the calculated from the measured gravities. From this it is evident that with increasing proportions of the isomorphous molecules the crystal lattice must change, this change being accompanied by an increase in the molecular volume. This is shown clearly in Fig. 4 where the percentage of $CaMg(Co_3)_2$ present in the different analyses are plotted as abscissas and their molecular volumes as ordinates. These molecular volumes were obtained by multiplying the molecular weights of the various molecules by their percentages and dividing the sum of these values by the measured specific gravity multiplied by 100. The molecular volumes of normal dolomite $CaMg(CO_3)_2$ is 64.2.

FIG. 4.

It is seen that for the change from 100 per cent to a little under 90 per cent of $CaMg(CO_3)_2$, the molecular volumes occur close to a horizontal line from this point and are spaced, nearly in equal degree, above and below it. But at the point of approximately 88 per cent $CaMg(CO_3)_2$ there is an increase in the molecular volumes which continues for the remainder of the series.

Such a change in molecular volumes from one end of an isomorphous series to the other is apparently a common thing. The various series of isomorphous salts that have been most carefully studied show this, although the fact does not seem to have been previously emphasized. For instance Rettgers[5] made studies of the following different series, all of which he proved to be strictly isomorphous. In each case the end members show different molecular volumes.

K_2SO_4(Mol. vol. = 65.4)—$(NH_4)_2SO_4$(Mol. vol. = 74.5)
$K_2SO_4.MgSO_4.6H_2O$(Mol. vol. = 197)—
$(NH_4)_2SO_4.MgSO_4.6H_2O$(Mol. vol. = 220)
$(NH_4)_2SO_4.MgSO_4.6H_2O$(Mol. vol. = 220)—
$(NH_4)_2SO_4.FeSO_4.6H_2O$(Mol. vol. = 244)
$Tl_2SO_4.Al_2(SO_4)_3.24H_2O$(Mol. vol. = 463)—
$K_2SO_4.Al_2(SO_4)_3.24H_2O$(Mol. vol. = 541)

In considering the crystal structure of the mixed-crystals of such a series we must assume, either that they contain in varying proportion two different molecules which have different molecular volumes and therefore different space lattices, or that the molecular volumes of the two molecules must progressively change and in any one specimen be identical. It does not seem possible to determine which of these two suppositions is the correct one but certainly the second seems more reasonable and logical. It can be conceived that the entrance of an isomorphous molecule into the composition of a salt would so affect the whole structure as to force a change in the volume of the unit cell of the crystal net-work. And this change would naturally increase with the rise in the percentage of the second molecule. This change in the spacing of the molecular layers in the crystal does not necessarily involve any change in their angular relations.

Another question arises in this connection. If we assume this change in the molecular volumes with change in composition, is it necessarily uniform from one end of the series to the other? In other words, does the presence of one per cent of an isomorphous molecule have the same effect proportionately upon the crystal structure as 25 per cent would have? The study of the molecular volumes of the dolomite analyses might suggest that

[5] Zs. Phys. Chem., 3, 497, 1889; 6, 235, 1890.

this change is not a uniform one. It might be considered that the structure and molecular volume of normal dolomite can be retained without change until slightly over 10 per cent of the isomorphous molecules are present, while after that point it must yield to their influence and show a progressive change. Under these conditions the line giving the change in molecular volumes or specific gravity with change in composition would be a curve and not a straight line. The broken line in FIG. 4 represents such a possible curve in the case of dolomite. As far as the writer is aware no careful survey has ever been made of the ends of a series of isomorphous salts that would serve to establish or contradict this possibility. The magnesite-siderite and siderite-rhodochrosite series discussed above were examined to see if they gave any evidence along this line. Only a few of these analyses showed a percentage of their chief constituent of 90 per cent or over and further the differences between the molecular volumes of the end members of the two series are about one half as great as in the case of the dolomite series. What evidence there was, seemed to confirm the above theory that the lattice remained constant for the end sections of the series, but it was not strong enough to enable one to make any definite statements in regard to it. Indeed, for the reasons given above, it could not be expected that the evidence in these series would be at all clear.

The straight solid line on FIG. 4 shows the variation in the molecular volumes of dolomite when it is considered that this change is uniform for the entire series. The theoretical specific gravities for the dolomites have been calculated from their analyses under this assumption and are given in column IV of TABLE V and the differences between these values and those measured are given in column V of the same table. It is interesting to compare these differences between the measured and theoretical values for the first twenty-five analyses with those derived under the assumption that the molecular volume remains uniform for this portion of the series. The average difference between the measured and calculated values for these twenty-five analyses as given in column V is .022 or if their positive and negative characters are considered, +.016. It will be seen that while the average error in this case is within allowable limits, it is notably greater than that given for the other case in a previous paragraph.

However, on the assumption that the change in molecular volume is uniform for the entire series the average of all the differences between the measured and calculated specific gravities, as given in column V of the table, is .026 or when the signs are considered, —.005. Considering the complexity of the problem and recognizing the fact that the changes in the specific gravity are not only due to the variation in percentages of the normal dolomite molecule present, but must also depend upon the possible variation in the amounts of the different isomorphous molecules, it is felt that the agreement between the calculated and measured values is, in general, surprisingly close.

From this it is seen that, whatever may be the true explanation of the physical changes involved in the chemical progression of dolomite, it is possible from its analysis to calculate closely what

TABLE VI

Data for Calculating the Specific Gravities of Dolomite

Percentage	$CaMg(CO_3)_2$	$CaFe(CO_3)_2$	$CaMn(CO_3)_2$	$CaCO_3$	$MgCO_3$
5	2.66	3.12	3.10		
10	2.67	3.13	3.11		
15	2.68	3.14	3.12		
20	2.69	3.16	3.14		
25	2.71	3.17	3.15		
30	2.72	3.18	3.16		
35	2.73	3.19	3.17		
40	2.74	3.21	3.19		
45	2.75	3.22	3.20		
50	2.76	3.23	3.21		
55	2.77	3.245	3.225		
60	2.78	3.26	3.24		
65	2.79	3.27	3.25		
70	2.80	3.28	3.26		
75	2.81	3.30	3.28	3.06	
80	2.825	3.31	3.29	3.07	
85	2.84	3.32	3.30	3.08	2.585
90	2.85	3.33	3.31	3.09	2.595
95	2.86	3.35	3.33	3.10	2.605
100	2.87	3.36	3.34	3.11	2.615

the specific gravity of a given specimen should be. Table VI gives the necessary data for making such calculations. In practice it has been found that with a number of problems to be calculated, it was simpler to obtain the required values by graph-

ical means. In making this table the solid straight line on FIG. 4 was assumed to represent the correct progression of the molecular volumes of dolomite with the variation in percentage of the normal dolomite molecule. The specific gravity of dolomite corresponding to the two end volumes was found to be 2.87 and 2.65. Interpolations between these end values give those recorded for every 5 per cent, as shown in the table. In the same way, the varying specific gravities for the other molecules were determined. If, for instance, the analysis showed 75 per cent of $CaMg(CO_3)_2$, the specific gravities of all the different molecules corresponding to this particular molecular volume would be found on the line of 75 per cent.

Part III. Relations between the Refractive Indices and Compositions of the Minerals of the Calcite Group

Some twenty-nine analyses of these minerals have been collected, with which the indices of refraction are recorded. A short study of these showed that the refractive indices varied directly with the composition and that given the percentages of the different carbonate groups present it was possible to calculate the indices that any specimen should show. In order to do this, it was first necessary to establish the refractive indices of the various pure carbonates. Calcite was apparently the only member of the group whose indices had been determined on theoretically pure material. Iceland spar, which is practically 100 per cent $CaCO_3$, has been repeatedly and very carefully tested. In the cases of the other molecules it was necessary to study the analyses and make some trial calculations before fixing upon their proper refractive indices. The values, as they were finally determined for the pure carbonates, were as follows;

	ω	ϵ
$CaCO_3$	1.658	1.486
$MgCO_3$	1.700	1.509
$MnCO_3$	1.817	1.597
$FeCO_3$	1.875	1.633

By using these numbers the theoretical indices for each analysis were calculated and are given in the columns headed "Calc." in Table VII, below. It will be seen that the agreement between these values and those determined by actual measurements is, in the majority of cases, very close and usually within the probable limits of error. There are two cases in which it seems clear that some error must exist in the determinations. The presumption is strong that the indices of the ordinary rays in Analyses 19 and 29 are wrong, since they show marked differences from the values given for other specimens of similar composition. With these two exceptions there are only four cases that show a difference between the measured and calculated indices for the ordinary ray greater than .004 and the same number in the case of the extraordinary ray that have a difference greater than .005. The average difference, still omitting Analyses 19 and 29, for the ordinary index is .004 or if the + and — signs are

TABLE VII

No.	$CaCO_3$	$MgCO_3$	$FeCO_3$	$MnCO_3$	Ordinary Ray			Extraordinary Ray			Locality	Ref.*
					Meas.	Calc.	Error	Meas.	Calc.	Error		
	100.0				1.658			1.486			Iceland	1
1	62.8	30.6	3.4	3.2	1.679†	1.683	+.004				Ouray, Col.	2
2	60.5	33.4	6.1		1.681†	1.685	+.004				Guanjuato, Mex.	2
3	53.8	45.0	1.2		1.681	1.679	—.002	1.502	1.498	—.004	Biskra	3
4	54.2	44.4	0.9	0.5	1.682	1.679	—.003	1.503	1.498	—.005	Traversella	4
5	54.5	43.7	1.8		1.683	1.680	—.003	1.503	1.499	—.004	Greiner	5
6	58.0	40.1	1.9		1.683†	1.679	—.004				Joplin	2
7	53.8	42.6	2.6	1.0	1.684†	1.685	+.001	1.504†	1.506	+.002	Vorderrheintal	6
8	55.0	42.2	2.8		1.685	1.682	—.003	1.505	1.500	—.005	Greiner	5
9	55.2	41.7	3.1		1.685	1.682	—.003	1.504	1.500	—.004	"	5
10	53.8	42.4	3.8		1.685	1.685	.000	1.505	1.501	—.004	"	5
11	54.8	35.1	4.1	6.0	1.685	1.689	+.004	1.505	1.507	+.002	"	5
12	60.3	31.3	8.4		1.685†	1.689	+.004				Guanjuato	2
13	54.5	41.2	4.3		1.686	1.685	—.001	1.505	1.502	—.003	Greiner	5
14	53.6	43.1	3.3		1.688	1.685	—.003	1.507	1.501	—.006	"	5
15	52.8	37.5	9.7		1.692	1.695	+.003	1.510	1.509	—.001	Traversella	7
16	52.6	36.7	11.7		1.698	1.715	+.007	1.513	1.526	+.013	"	5
		100.0			1.700			1.509				
17	19.1	31.2	10.9	38.8	1.700	1.756	+.056	1.515	1.552	+.037	Greiner	5
18	3.4	91.5	5.1		1.707†	1.707	.000	1.517†	1.515	—.002	Veitsch	8
19			9.5	90.5	1.715	1.822	+.107					
20	48.3	11.3	37.9	2.5	1.741†	1.749	+.008	1.536†	1.547	+.007	Erzberg, Styria	6
21		49.8	50.2		1.788†	1.788	.000	1.570†	1.571	+.001	Traversella	8
				100.0	1.817			1.597				
22	0.8		19.9	79.3	1.826†	1.827	+.001	1.605†	1.603	—.002	Branchville	8
23	1.3	23.3	73.2	2.2	1.830†	1.830	.000	1.596†	1.601	+.005	Allevard	8
24	0.6	17.9	76.8	4.7	1.838†	1.839	+.001	1.603†	1.608	+.005	Bindt	6
25	1.6	9.1	83.6	5.7	1.847†	1.852	+.005	1.613†	1.616	+.003	Roxbury	6
26	0.4	6.6	77.2	15.8	1.849†	1.853	+.004	1.615†	1.618	+.003	Neudorf	6
27			95.9	4.1	1.872†	1.872	.000	1.634†	1.631	—.003	Greenland	6
28	0.2	0.3	97.7	1.8	1.873	1.873	.000	1.634	1.630	—.004	Cornwall	9
			100.0		1.875			1.633				
29	0.8	4.6	76.8	16.8	1.934	1.837	—.097	1.632	1.604	—.028	Wolfsberg	

* (1) Schrauf, Zs. Kr., **11**, 13, 15, 1885. (2) Foote and Bradley, Am. J. Sc., **37**, 343, 1914. (3) Hutchinson, Rep. Brit. Assoc., 701, 1908. (4) Fizeau and Damour, quoted by Born, N. Jb. Min. Beil.-Bd., **5**, 12, 1887. (5) Eisenhuth, Zs. Kr., **35**, 584 *et seq.*, 1901. (6) Unpublished analysis by author. (7) Born, N. Jb. Min., Beil.-Bd., **5**, 4, 1887. (8) Unpublished analysis by W. M. Bradley. (9) Hutchinson, Min. Mag., **13**, 209, 1903. (10) Ortloff, Zs. Phys. Chem., **19**, 215, 1896.

† Determinations made by the author.

considered, —.003; for the extraordinary index the average difference is .005 or —.001. If Analysis 17 could also be eliminated it would make these differences still smaller, but including this, the averages are well within the allowable limits. There can be, therefore, no doubt but that the refractive indices for these minerals do vary directly with the composition and can be calculated from the analyses with considerable precision.

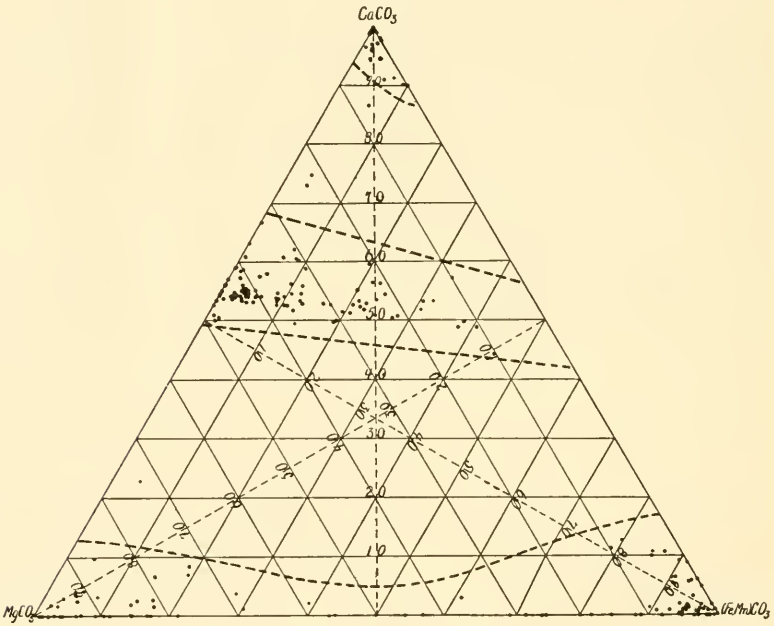


Fig. 5.

It may be pointed out here that the small variations in molecular volumes that these minerals show and which have a distinct influence upon their specific gravities, have no apparent effect upon their refractive indices. The latter would, therefore seem to be controlled by the elements present and their arrangement in the molecular net-work but not by the spacing of the molecular planes.

It will be of interest to combine the relations existing between the chemical composition of these minerals and both their specific gravities and refractive indices in order to see how far we can

go in predicting the composition of a given specimen, having determined these physical characters. This is best done by means of triangular projections. Fig. 5 shows the complete triangular projection for $CaCO_3$-$MgCO_3$-$(Fe,Mn)CO_3$, with the positions indicated upon it of all the analyses of these minerals that have been collected. The heavy broken lines show the probable limiting boundaries of the various isomorphous mixtures. We need, therefore, to consider only these portions of the

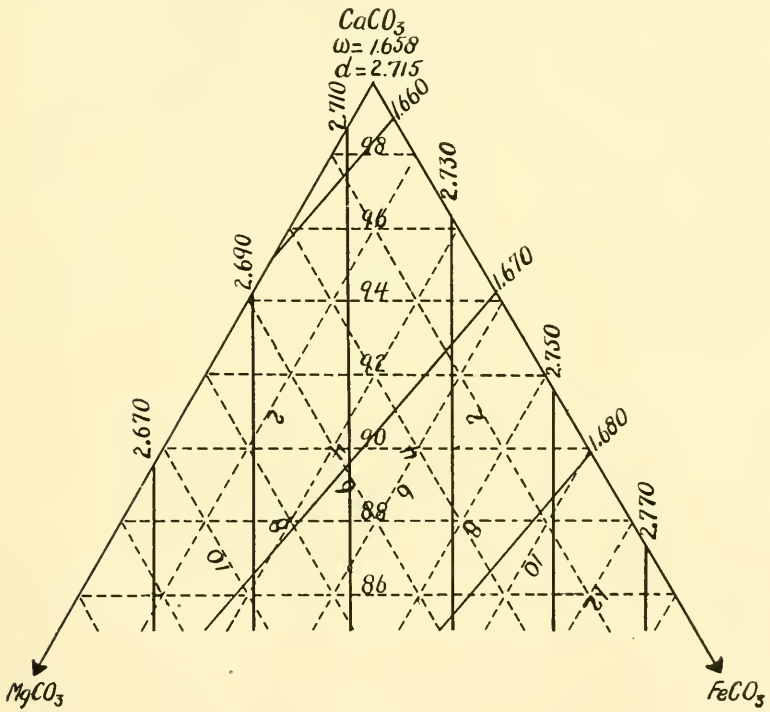


Fig. 6.

entire projection. Fig. 6 shows the calcite end of the series with the lighter solid lines within the figure indicating the loci of various combinations of molecules that would possess the same refractive index. In a similar way the heavier solid lines indicate the specific gravities. The refractive index lines have the same direction and spacing in all portions of the triangular projection but the lines of the specific gravities change in the

different sections of the field. This irregularity of the specific gravities was pointed out above. In the case of the calcite portion of the field these lines are practically vertical and cross those

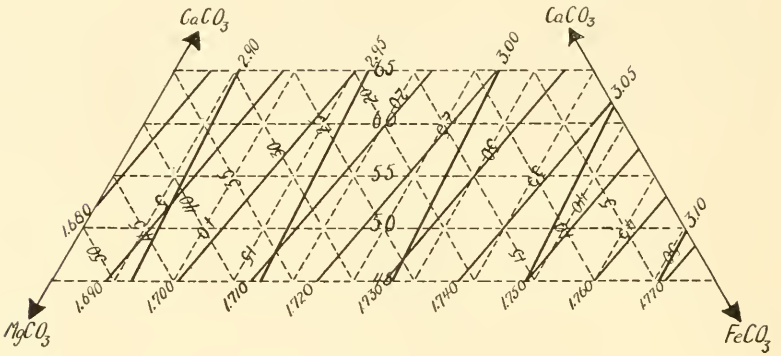


Fig. 7.

of the refractive indices at fairly blunt angles. Fig. 7 shows the portion of the projection occupied by dolomite with the lines of equal refractive indices and specific gravities shown by the solid

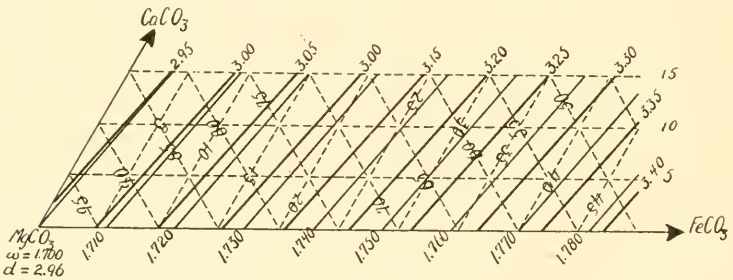


Fig. 8.

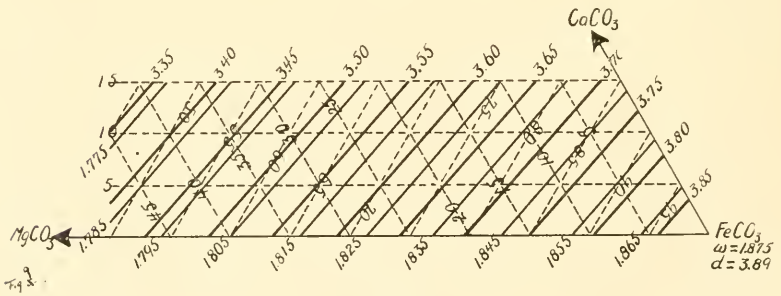


Fig. 9.

lines. It will be noted that these two sets of lines cross each other in this case, at quite sharp angles. Figs. 8 and 9 show respectively the $MgCO_3$ and the $FeCO_3$ ends of the $MgCO_3$-$FeCO_3$ series. Here the two sets of lines become practically parallel to each other. It should be stated that the lines of equal refractive index and specific gravity give the percentages of $CaCO_3$, $MgCO_3$ and $FeCO_3$ and do not consider the possible presence of $MnCO_3$. However, the position of the lines would not be very materially changed, even if a considerable amount of manganese carbonate should be present, since its characters are fairly close to those of ferrous carbonate.

While no claim can be made that the exact composition of a mineral of this group can be determined by means of its physical constants and the use of these figures, it should still be possible from them, to place approximately the composition of the specimen, especially if a further guide was provided by making qualitative chemical tests upon it. In any event these figures show in simple graphical form the relations that exist between the chemical composition and the specific gravities and refractive indices of the members of the Calcite Group.

Appendix

For the sake of making the record complete the following new analyses and physical determinations, which were made during this study and which have been used in it, are given in separate form. Analyses numbered I to IV were made by Dr. Walter M. Bradley to whom the author's thanks are especially due. The other analyses and all the physical determinations were made by the writer.

	I.	II.	III.	IV.	V.
	Rhodochrosite Branchville, Conn.	Magnesite Veitsch, Styria	Mesitite Traversella, Piedmont	Siderite Allevard, France	Dolomite Vorderrheintal, Switzerland
d	3.743	3.029	3.374	3.633	2.890
ω	1.8279	1.7073	1.7878	1.8303	1.6839
ϵ	1.6057	1.5168	1.5703	1.5958	1.5037
CaO	0.47	1.88		0.73	30.64
MgO		43.76	23.92	11.15	20.77
FeO	12.50	3.20	31.22	45.46	1.63
MnO	49.56			1.27	0.63
CO_2	[37.06]	50.84	[44.86]	[41.39]	46.71
Insol.		0.18			
Total	100.00	99.86	100.00	100.00	100.38

	VI.	VII.	VIII.	IX.	X.
	Ankerite Erzberg, Styria	Siderite Roxbury, Conn.	Siderite Ivigtut, Greenland	Siderite Neudorf, Harz Mts.	Siderite Bindt, Hungary.
d	3.121	3.793	3.951	3.813	3.707
ω	1.7409	1.8472	1.8724	1.8490	1.8376
ϵ	1.5360	1.6128	1.6339	1.6148	1.6030
CaO	27.56	0.89		0.21	0.36
MgO	5.54	4.45		3.17	8.68
FeO	23.98	52.85	60.10	48.37	48.41
MnO	1.58	3.58	2.57	9.87	2.92
CO_2	[41.34]	[38.23]	[37.33]	[38.38]	[39.63]
Total	100.00	100.00	100.00	100.00	100.00

Mineralogical Laboratory of the Sheffield Scientific School of Yale University, New Haven, Conn., May 1st, 1917.

For particulars regarding the previous Transactions of the Connecticut Academy,

Address the Librarian,
Andrew Keogh, Yale Station,
New Haven, Conn., U. S. A.

CONTENTS OF VOLUME 21 OF THE TRANSACTIONS

PAGES		PRICE
1–144	The Last Months of Chaucer's Earliest Patron, by Professor Albert S. Cook (Dec. 1916)	$1.60
145–200	The Relationship of the Tetracoralla to the Hexacoralla, by W. I. Robinson (Feb. 1917)	.40
201–313	The American Species of Marchantia, by Alexander W. Evans (March, 1917)	1.20
315–442	A Survey of Ancient Peruvian Art, by Philip Ainsworth Means (May, 1917)	1.50

CONTENTS OF VOLUME 22 OF THE TRANSACTIONS

PAGES		PRICE
1–209	The History of Early Relations between the United States and China, 1784-1844, by Kenneth Scott Latourette (Aug. 1917)	$2.20
211–248	Studies in the Calcite Group, by William E. Ford (Oct. 1917)	.45

JUL 17 1918

4370

LIBRARY
MUS. COMP. ZOOLOGY

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 22, PAGES 249-467 JUNE, 1918

The Vegetation
OF
Northern Cape Breton Island, Nova Scotia

BY

GEORGE E. NICHOLS, Ph.D.,

ASSISTANT PROFESSOR OF BOTANY IN THE SHEFFIELD SCIENTIFIC SCHOOL
OF YALE UNIVERSITY

YALE UNIVERSITY PRESS

NEW HAVEN, CONNECTICUT

1918

JUL 17 1918

TRANSACTIONS OF THE
CONNECTICUT ACADEMY OF ARTS AND SCIENCES
INCORPORATED A. D. 1799

VOLUME 22, PAGES 249-467 JUNE, 1918

The Vegetation
OF
Northern Cape Breton Island, Nova Scotia

BY

GEORGE E. NICHOLS, Ph.D.,

ASSISTANT PROFESSOR OF BOTANY IN THE SHEFFIELD SCIENTIFIC SCHOOL
OF YALE UNIVERSITY

YALE UNIVERSITY PRESS

NEW HAVEN, CONNECTICUT

1918

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

CONTENTS

Page

INTRODUCTION 257

I. GENERAL PHYTOGEOGRAPHIC RELATIONS OF THE REGION 257

II. PREVIOUS BOTANICAL INVESTIGATIONS, AND FIELD WORK OF THE AUTHOR 261

III. ACKNOWLEDGMENTS 263

IV. PHYSIOGRAPHY 263

V. CLIMATE 269

VI. ECOLOGICAL CLASSIFICATION OF MATERIAL; NOMENCLATURE 274

THE DECIDUOUS FOREST CLIMATIC FORMATION IN NORTHERN CAPE BRETON 278

I. THE REGIONAL CLIMAX ASSOCIATION-TYPE: THE CLIMAX FOREST 278

II. THE EDAPHIC FORMATION-COMPLEX OF THE REGION 294

A. Primary Formations of the Xerarch Series 294

1. The Formation-types of Ordinary Uplands 294

a. Introductory 294

b. The Association-complexes of Rock Outcrops 295

c. The Association-complexes of Glacial Drift 300

d. The Association-complexes of Talus 302

2. The Formation-types of Uplands along Streams 306

a. Introductory 306

b. The Association-complexes of Rock Ravines 309

c. The Association-complexes of Open Valleys 314

d. The Association-complexes of Boulder Plains 315

e. The Association-complexes of Flood Plains 317

3. The Formation-types of Uplands along the Seacoast ... 319

a. Introductory 319

b. The Association-complexes of Sea Bluffs and Headlands 319

c. The Association-complexes of Beaches and Dunes .. 324

Page

B. Secondary Formations of the Xerarch Series 334
Formation-types resulting primarily from Human Activity 334
a. Association-complexes due to Cultivation 334
b. Association-complexes due to Fire 341
c. Association-complexes due to Logging 346

C. Primary Formations of the Hydrarch Series 347
1. The Formation-types of Lakes and Ponds Inland 347
a. Introductory 347
b. The Association-complexes of Well-drained Lakes and Ponds 350
c. The Association-complexes of Undrained Lakes and Ponds 353

2. The Formation-types of Lake- and Spring-swamps Inland 354
a. Introductory 354
b. The Association-complexes of Well-drained Swamps 356
c. The Association-complexes of Undrained Swamps .. 359
d. The Association-complexes of Poorly Drained Swamps 364

3. The Formation-types in and along Rivers and Streams 368
a. Introductory 368
b. The Association-complexes of Ravines 369
c. The Association-complexes of Flood Plains 371

4. The Formation-types along the Seacoast 374
a. Introductory 374
b. The Association-complexes of Salt and Brackish Lakes and Ponds 375
c. The Association-complexes of Salt Marshes 376
d. The Association-complexes of Brackish Marshes ... 379

D. Secondary Formations of the Hydrarch Series 383
Formation-types resulting primarily from Human Activity 383
Association-complexes due to Various Agencies 383

THE NORTHEASTERN EVERGREEN CONIFEROUS FOREST CLIMATIC FORMATION IN NORTHERN CAPE BRETON 385

I. GENERAL CONSIDERATIONS 385

II. THE REGIONAL CLIMAX ASSOCIATION-TYPE: THE CLIMAX FOREST 389

III. THE EDAPHIC FORMATION-COMPLEX OF THE REGION 395

Page

A. Preliminary Observations 395

B. Formations of the Xerarch Series 396

1. The Formation-types of Ordinary Uplands in the Forested Region 396

a. The Association-complexes of Well-drained Uplands 396

b. The Association-complexes of Poorly Drained Uplands 397

2. The Formation-types of Ordinary Uplands in the Barrens 399

a. The Association-complexes of Well-drained Uplands 399

b. The Association-complexes of Poorly Drained Uplands 413

3. The Formation-types of Uplands along Streams 414

The Association-complexes of Ravines and Valleys 414

C. Formations of the Hydrarch Series 415

1. The Formation-types of Lakes and Ponds 415

a. Introductory 415

b. The Association-complexes of Well-drained Lakes and Ponds 416

c. The Association-complexes of Undrained Ponds 417

2. The Formation-types of Lake-, Spring-, and Precipitation-swamps 418

a. The Association-complexes of Well-drained Swamps 418

b. The Association-complexes of Poorly Drained Swamps 419

c. The Association-complexes of Undrained Swamps .. 422

d. The Association-complexes of Raised Bogs 433

3. The Formation-types of Swamps along Streams 456

The Association-complexes of Ravines and Flood Plains 456

SUMMARY 459

BIBLIOGRAPHY 463

INDEX OF TABLES

I. Temperature and precipitation records at Sydney, Nova Scotia 270

II. Temperature and precipitation data at selected stations in eastern Canada 270

III. Evaporation rate along the coast in northern Cape Breton 272

IV. Temperature in the interior and along the coast of northern Cape Breton 273

V. Quadrat studies in hardwood forest; Barrasois 286

VI. Evaporation rate in various habitats; Barrasois 314

LIST OF FIGURES

		Page
1.	Map of eastern North America, showing position of Cape Breton with reference to the Transition Forest Region	258
2.	Map of northern Cape Breton, showing distribution of forest regions and barrens	260
3.	Lowland and plateau, viewed from Middle Head, Ingonish	264
4.	View across forested portion of plateau	265
5.	View southward along coast from near summit of Smoky	266
6.	Ingonish Harbor and Mt. Smoky	266
7.	Lower end of Big Intervale, Aspy Bay	267
8.	Mountains and lowland along coast north of Cheticamp	268
9.	Second growth woodland in lowland; Barrasois	278
10.	Primeval climax forest; Northeast Margaree	279
11.	Primeval climax forest; Indian Brook	281
12.	Primeval climax forest; Barrasois	282
13.	Balsam fir wind-fall; Adirondacks, New York	290
14.	Granitic talus, north of Cheticamp	302
15.	Gypsum outcrop along Ingonish Harbor	305
16.	Pioneer growth of white spruce on granitic talus; Barrasois	306
17.	Valley along lower course of Barrasois River	307
18.	Boulder plain along Barrasois River	308
19.	Gorge along Indian Brook	310
20.	Upper end of Big Intervale, Aspy Bay	315
21.	Boulder plains and flood plains along Middle River	316
22.	*Juniperus horizontalis* on sea bluff; Middle Head, Ingonish	320
23.	*Alnus mollis* and *Picea canadensis* on clay sea bluff; Cape North	321
24.	Exposed headland; White Point	322
25.	Vegetation on exposed headland; White Point	323
26.	Shingle beach enclosing fresh pond; Wreck Cove	325
27.	Shingle beach; Barrasois	326
28.	Spit with sand and shingle; Barrasois	327
29.	Stunted firs on shingle beach; Barrasois	329
30.	Sand spit at Aspy Bay	330
31.	Sand dunes with *Picea canadensis;* Aspy Bay	331
32.	Sand dunes with *Poa compressa;* Aspy Bay	332
33.	Abandoned pastures, etc., along St. Ann's Bay	334
34.	Abandoned field with white spruce and *Dicksonia;* Barrasois	336
35.	Fir and spruce reproduction in abandoned field; Barrasois	337
36.	Grove of white spruce in abandoned pasture; Barrasois	339
37.	Forest succession in a burned area; Maine	342
38.	Barrens and second growth forests along coast north of Neil's Harbor	343
39.	White spruce reproduction after cutting and burning; Ingonish	344
40.	Blueberry barren near Frizzleton	345
41.	Freshwater Lake; South Bay, Ingonish	349
42.	Fresh pond behind shingle beach; Barrasois	351

Page

43. Bog near mouth of Barrasois River 360
44. Diagrammatic sections of poorly drained swamps; Broadcove Mountain 365
45. Salt marsh; Aspy Bay 377
46. Brackish marsh; Barrasois 380
47. Primeval coniferous forest in mountains near Cape North 386
48. Barrens in mountains north of Barrasois 388
49. Primeval coniferous forest in mountains north of Barrasois 390
50. Low coniferous woodland on plateau 397
51. General view of barrens, with heath, etc. 398
52. Dwarf shrub–spruce heath in barrens 401
53. Hummock in dwarf shrub–spruce heath 403
54. *Krummholz* and low woodland in barrens 406
55. Low *Krummholz* association-type in barrens 407
56. Gnarled tamaracks on exposed summit in barrens 409
57. Habit sketch of balsam fir, growing in forest scrub 410
58. Weather beaten balsam fir in barrens 412
59. Ravine forest in barrens 414
60. Small lake in mountains; aquatic vegetation and narrow marginal fringe of swamp shrubs 416
61. Small lake in mountains with border of marshy swamp 420
62. Undrained pool, with marginal vegetation, in raised bog in barrens 427
63. Characteristic mountain bog 431
64. Raised bog; Peter's Barren 433
65. Diagrammatic representation of bog complex in barrens 437
66. Raised bog in barrens 438
67. Wet bog and bog meadow in shallow valley in barrens 442
68. Wet bog and forest scrub in barrens 444
69. Pools on surface of raised bog in barrens 454
70. Shallow, flat-floored stream valley in barrens 457

INTRODUCTION

I. GENERAL PHYTOGEOGRAPHIC RELATIONS OF THE REGION

Viewed from the standpoint of ecological plant geography, the vegetation of the forested portions of eastern North America, north of southern Florida, comprises two great climatic formations: the Deciduous Forest Formation and the Northeastern Evergreen Coniferous Forest Formation. Viewed from the standpoint of floristic plant geography, it is possible to subdivide the vegetation of this area still further (in this connection see especially Transeau '05, Harshberger '11, Shreve '17), but from the ecological point of view, as will be emphasized later, the advisability of such subdivision is at least open to question.

The deciduous forest formation attains its highest and most typical development in the lower Ohio basin and the southern Appalachians, where the climax forests are made up almost wholly of deciduous trees. These include a wealth of species, prominent among which are beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*), chestnut (*Castanea dentata*) and tulip (*Liriodendron Tulipifera*), red oak (*Quercus rubra*), white oak (*Quercus alba*), hickory (especially *Carya alba*), and white ash (*Fraxinus americana*). The evergreen coniferous forest formation attains its optimum development in middle-eastern Canada. Here the climax forests are relatively poor in species, consisting mainly of balsam fir (*Abies balsamea*), white spruce (*Picea canadensis*) and black spruce[1] (*Picea mariana*), with which is associated the paper birch (*Betula alba papyrifera*).

[1] In all the current manuals a distinction is made between the black spruce and the red spruce (*Picea rubra*). After several years of experience in the north-woods, the writer is obliged to confess his inability to differentiate with certainty between the two, an inability which he finds to be shared by many other botanists. It is his opinion that the red spruce at best should be regarded merely as a variety of the black spruce, the status which it formerly held. To be sure, the small, impoverished bog form of this tree (the typical *P. mariana* of the manuals) does appear very distinct when compared with the large, thrifty upland form (which typifies *P. rubra*); but there are all sorts of intergradations between these two

Midway between these two regions (see map, Fig. 1), is situated the Transition Forest Region, a broad zone in which, due to the overlap in the ranges of the southern and northern climax

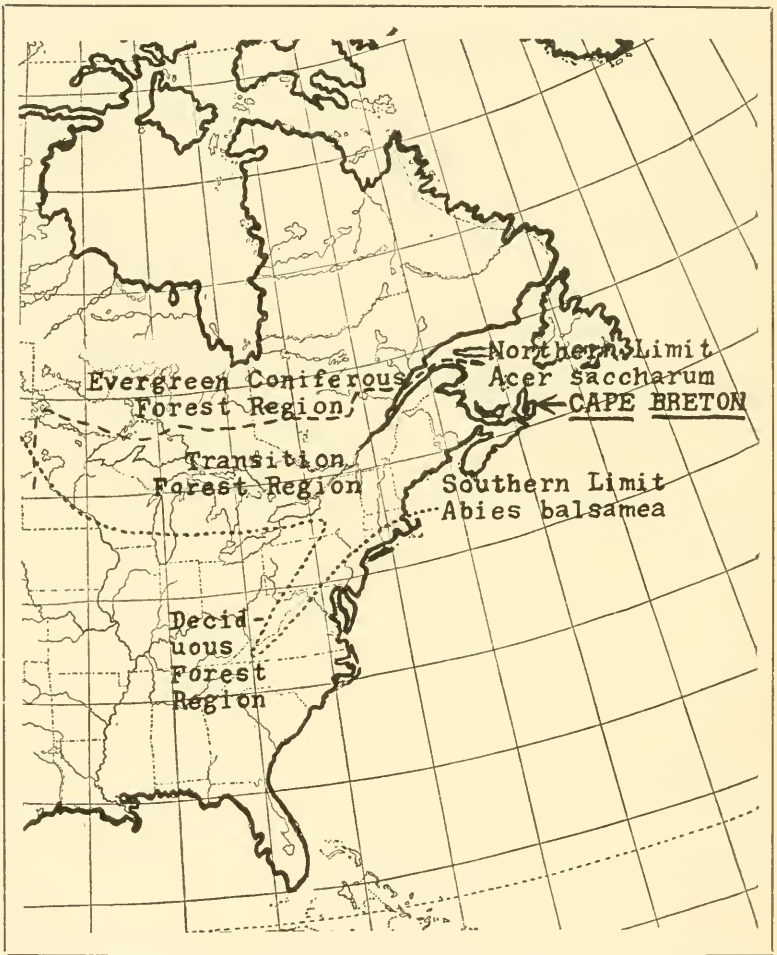


Figure 1.—Map of eastern North America, to show position of Cape Breton Island with reference to the Transition Forest Region.

extremes. Moreover, especially in these intermediate forms, the structural dissimilarities upon which the manuals lay stress in attempting to differentiate two distinct species, are far from satisfactory in their application. In the present paper no attempt is made to distinguish *P. rubra* from *P. mariana*, although it is appreciated that much of the upland spruce may perhaps well be referred to the former "species."

trees, the nature of the climax forest, taken in its entirety, is intermediate between that of the evergreen coniferous, and that of the deciduous climatic formation, as most typically developed: where, in other words, the two formations are telescoped. This region represents a great tension zone, in which competition between the northern and southern climax trees is still in active progress, and where, as a result, it is possible to study the ecological relations of the two groups of species concerned. The northern boundary of this transition region is determined by the northern outposts of the deciduous climax trees of the deciduous forest formation: it may be regarded as coinciding approximately with the northern limit of the sugar maple (see, in this connection, Cooper '13, pp. 36–39). In the same way, the southern boundary of the transition region may be said to be determined by the southern outposts of the climax trees of the evergreen coniferous forest formation, in so far as these grow on uplands: it may be regarded as coinciding roughly with the southern limit of the balsam fir. These boundaries are indicated on the map (Fig. 1), but the lines as drawn can represent little more than a rough approximation; for, owing largely to variations in topography, at higher elevations the evergreen coniferous forest formation locally extends far to the south of the northern boundary, while at lower elevations the deciduous forest formation is typically developed considerable distances north of the southern boundary of the transition region, as here represented.

From the standpoint of floristic plant geography it is significant that the geographic center of distribution for the so-called Canadian element in the flora of eastern North America lies within this transition region. Many Canadian species are practically confined to this area, prominent examples of this latter group, among the woody plants, being *Pinus Strobus* and *P. resinosa, Tsuga canadensis, Betula lutea, Acer pennsylvanicum,* and *Viburnum alnifolium.* But while, from the floristic point of view, the vegetation of this region certainly is more or less unique, from an ecological point of view it is doubtfully to be regarded as a distinct climatic formation. And while its intermediate character is generally recognized, nevertheless, largely because of the almost universal supremacy, in situations edaphically favorable to their development, of the climax trees of the deciduous forest formation over those of the northeastern evergreen conifer-

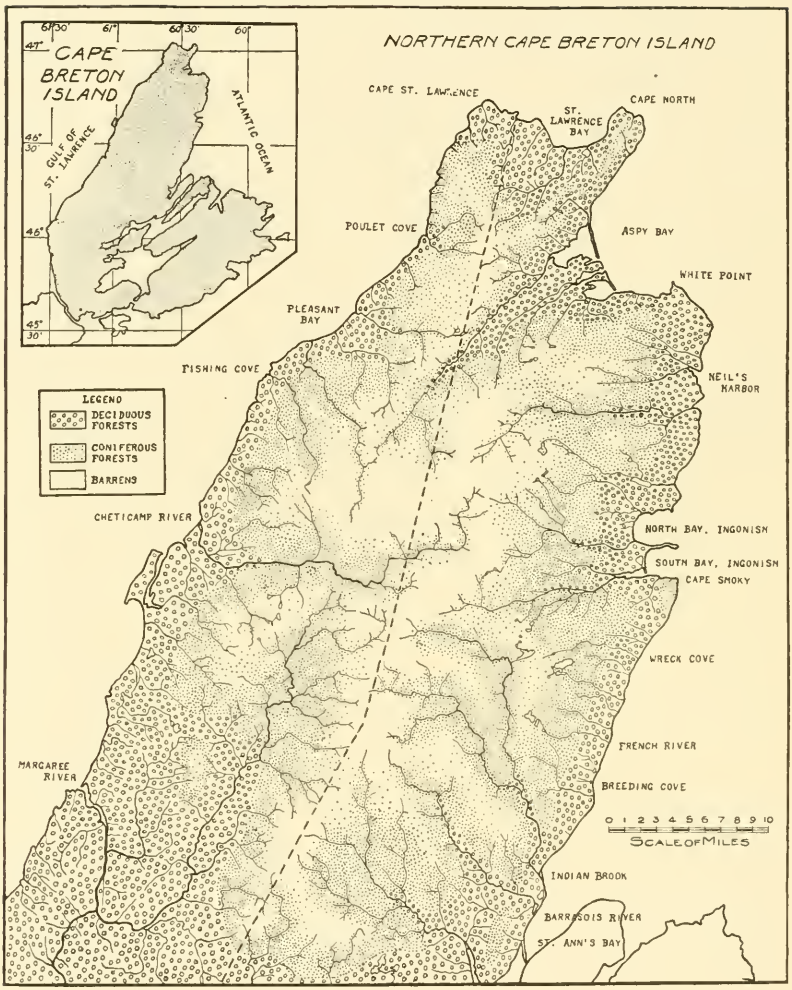


FIGURE 2.—Map of northern Cape Breton, showing approximate distribution of deciduous forest climatic formation and northeastern evergreen coniferous forest climatic formation. The unshaded areas are very largely occupied by barrens. Inserted map: Cape Breton Island, together with a small portion of the peninsula of Nova Scotia.

ous forest formation, wherever these two groups come into competition with one another, from the standpoint of ecological plant geography it seems best, on the whole, to regard the vegetation of this transition region as constituting merely the northward extension of the deciduous forest formation.

As a glance at the map (FIG. 1) will show, Cape Breton Island, located northeast of the peninsula of Nova Scotia (lat. 45° 30′–47° N.; long. 60° 15′–61° 30′ E.), and separated from the mainland only by the Gut of Canso, a narrow strait scarcely a mile wide, is situated near the northern edge of the transition forest region. In northern Cape Breton, owing chiefly to differences in climate at different elevations, both the deciduous forest formation and the northeastern evergreen coniferous forest formation are well represented: the former predominates from sea level up to an altitude of about 700 feet; the latter prevails at higher elevations. The approximate distribution in this region of these two formations is mapped in FIG. 2. The vegetation of the Barrens, which occupy the highest parts of the plateau, apparently bears much the same relationship to the evergreen coniferous forest formation on the one hand and the arctic tundra on the other that the vegetation of the transition forest region bears to the deciduous forest formation and the evergreen coniferous forest formation respectively: it seems to represent a transition between evergreen coniferous forest, as typically developed, and tundra. For various reasons the barrens have been mapped as distinct, but their vegetation is to be regarded merely as the upward extension of the evergreen coniferous forest formation.

II. PREVIOUS BOTANICAL INVESTIGATIONS, AND FIELD WORK OF THE AUTHOR

Aside from the work of Ganong ('91, '93, etc.) and Transeau ('09), practically no investigations of a purely ecological nature have been conducted in the Maritime Provinces of eastern Canada (New Brunswick and Nova Scotia). The present paper aims to portray in a general way the ecological relations of the vegetation in a portion of this area.

So far as is known to the writer, only three other botanists—John Macoun ('83–'02, '98), C. B. Robinson ('03, '04, etc.), and

J. R. Churchill—have undertaken any explorations in northern Cape Breton. Aside from the work of these three, which was almost wholly taxonomic, scattered observations of general botanical interest are recorded in the report on the geology of this region ('85) by Hugh Fletcher, the pioneer geologist whose detailed maps, constructed more than thirty years ago, have afforded the basis for all subsequent explorations; while B. E. Fernow, on the basis of a survey made for commercial purposes, has briefly described the forests here, with an accompanying map, in his account of the forest conditions of Nova Scotia ('12).

The writer's acquaintance with northern Cape Breton dates back to 1905 when about three weeks were occupied in a tramp along the coast from Baddeck to Ingonish, across the island from North River to Northeast Margaree, and thence back to Baddeck. It was on this trip that the curly grass fern (*Schizaea pusilla*) was first recorded from Cape Breton (see Nichols '05). In 1909, a month was spent in camp near the mouth of the Barrasois River, but beyond the collection and identification of mosses and liverworts no serious botanical work was attempted. The investigations embodied in the present paper were projected in 1913 and have been carried on for parts of four summers. Altogether, during this time, more than six months have been occupied by field work in northern Cape Breton. In 1914, and again in 1915, a base camp was maintained for about a month along the lower course of the Barrasois River (St. Ann's), from which point excursions were made into the surrounding country, while another month was spent at various points along the eastern coast, between St. Ann's Bay and Aspy Bay, and in the interior. During the summer of 1916 the entire length of the coast from St. Ann's Bay to Cape North was traversed on foot, and a week was spent in the interior. On this trip the writer was accompanied by Dr. L. H. Harvey, whose experience in the Mt. Ktaadn region suggested many interesting comparisons. The first draft of the present paper was prepared during the college year 1916-1917, and in the summer of 1917 another month was spent in the field, partly for the purpose of checking up previous observations, partly with the object of visiting the western coast of the area under consideration. On this trip, starting from Baddeck, the author traveled to Middle River, Northeast Margaree and Margaree Harbor, thence along the coast to Cheticamp and Pleasant Bay, across the

island to Aspy Bay, and from here to Ingonish, from which point another excursion was made into the interior.

As a desirable adjunct to the ecological investigations, considerable attention has been devoted to the flora of the region: two papers on the bryophytes of Cape Breton have already been published ('16[a], '18), and a similar catalogue of the vascular plants is contemplated. Incidentally, in addition to the studies in northern Cape Breton, the writer has recently visited two other widely separated areas within the transition region: in the spring of 1916 a week was spent at the Yale Forest School Camp near Brandreth, in the western Adirondacks; while during the summer of 1917 nearly a month was occupied, in company with Dr. Harold St. John of the Gray Herbarium, in exploring the upper waters of the St. John River, in northwestern Maine. Also, in connection with the study of raised bogs in northern Cape Breton, a visit was made, in 1917, to one of the New Brunswick bogs described by Ganong ('91, '97).

III. ACKNOWLEDGMENTS

The writer wishes to express his indebtedness to Professor Alexander W. Evans for his continued interest in this work throughout its progress; to Mr. Albert F. Hill, Professor Merritt L. Fernald, Dr. Harold St. John, and Mr. Charles A. Weatherby, who have determined or passed judgment on the vascular plants collected; to Professors A. Le Roy Andrews and Lincoln W. Riddle, who have determined the sphagnums and lichens respectively; and to various others (see Nichols '16[a]), who have assisted in the determination of the bryophytes.

IV. PHYSIOGRAPHY

Cape Breton Island is about 4,000 square miles in area: it is approximately four-fifths as large as the state of Connecticut. Its greatest length (from the Gut of Canso to Cape North) is about 110 miles, its greatest width (from Margaree Harbor to Cape Breton) about 75 miles. The general configuration of the island is brought out by the map (Fig. 2). It comprises two distinct peninsulas, which are united at the south by the narrow Isthmus

of St. Peter (now cut by a ship canal), and which almost completely enclose the Bras d'Or Lakes, an irregularly shaped mediterranean sea fifty miles long and in places twenty miles wide. The area treated as northern Cape Breton in the present paper is about sixty miles long with a maximum width of about thirty miles.

A good idea of the general character of the country is conveyed by the accompanying series of photographs. In addition

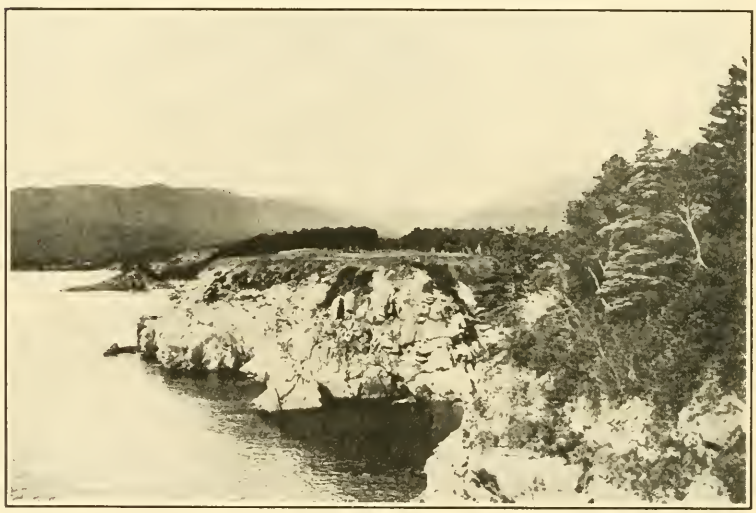


FIGURE 3.—View of lowland and plateau from Middle Head, Ingonish: in upper right background, Mt. Franey; to left of this, valley of Clyburn Brook; in foreground, low granitic headland, drift-covered, with second growth forests of white spruce and balsam fir.

to those introduced in the present connection, attention is especially called to the following: FIGS. 21, 24, 26, 28, 30, 33, 38, 41, 50, 51.

From a topographic standpoint the outstanding feature of northern Cape Breton is the great interior plateau, which stretches in almost unbroken continuity from Cape North nearly to the Bras d'Or. This massive remnant of the ancient Atlantic Upland (Goldthwait '16), composed of granites, syenites, and other highly resistant, crystalline rocks of Laurentian age, includes the highest land in Nova Scotia. The average elevation of its sur-

face in northern Cape Breton is between 1,000 and 1,200 feet, but in places it is considerably higher.[2] South of the area under discussion the plateau becomes greatly fragmented and its surface gradually approaches sea level. In southeastern Cape Breton the summits of the Laurentian highlands rarely attain an elevation of more than 300 feet.

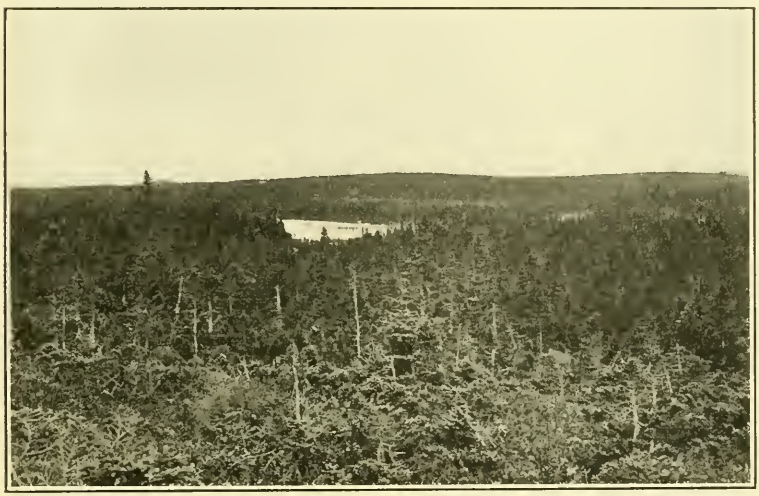


FIGURE 4.—Characteristic view on the plateau: looking westward from an eminence north of the Barrasois River; primeval forests of balsam fir, etc.

As one approaches the eastern coast of northern Cape Breton in the little coasting steamer, which affords the easiest means of travel along the shore north of Sydney, the plateau, as viewed in the distance, presents an even, unbroken skyline (see especially FIG. 30). But to one standing on the summit of Mount Franey, or some other eminence along the eastern margin of the table-land, its surface appears as a broad expanse of low, rounded hills, which stretches westward to the horizon (FIGS. 4, 51). Hidden away among these distant hills are innumerable little lakes and ponds, countless deep valleys and wild gorges.

[2] Mount Franey (FIG. 3), the loftiest hill recorded, measures 1,370 feet in height. In the opinion of the writer there are numerous higher summits in the interior of the island.

FIGURE 5.—View looking southward along coast from near summit of Mt. Smoky: Carboniferous lowland in mid-distance; elsewhere the underlying rocks are crystalline.

FIGURE 6.—Ingonish Harbor: Mt. Smoky (granitic) in distance, with lower Carboniferous hills and the shingle spit which partly encloses the harbor in mid-distance; Carboniferous lowland in foreground.

Along certain sections of the coast in northern Cape Breton the crystalline rocks extend bluffly out to the shore. In places, as between Aspy Bay and Neil's Harbor (Fig. 38), these rugged granitic shores are relatively low. Elsewhere, as at Cape North (Fig. 30) and Cape Smoky (Fig. 6), the mountains rise abruptly from the sea: at Cape Smoky and along the northwest shore are magnificent sea cliffs many hundred feet in height. But along much of the coast, a low border of Carboniferous rocks—sand-

Figure 7.—The Big Intervale at Aspy Bay: farms and second growth forests; *Pyrus americana* in right foreground.

stone, shale, dolomite, gypsum, etc.—intervenes between the crystalline area and the sea. On the eastern shore (Figs. 5, 26, 33), and on the western shore north of Cheticamp, this fringe of softer rocks is rarely more than a mile in width; ordinarily it is much less. At certain places even here, however, as at North River, Ingonish, Aspy Bay (Figs. 7, 20), Bay St. Lawrence, and Pleasant Bay, the Carboniferous lowland extends inland for several miles along the rivers, forming broad intervales. In the southwestern part of the area mapped (Fig. 2), in the Margaree district, the lowlands are much more extensively developed than elsewhere (Fig. 21).

It has been inferred by some geologists that Cape Breton Island escaped glaciation, and this has been assumed as a hypothesis by certain botanists (Robinson '06, p. 258; Taylor '12, p. 24), in an attempt to explain certain peculiarities of plant distribution. Such, however, is hardly the case. On the plateau, to be sure, superficial deposits of any depth are scarce, the rock surface often being bare or covered with granite boulders of apparently local origin. Soil, when present, is usually thin:

FIGURE 8.—Mountains and granitic, drift-covered lowland north of Cheticamp.

commonly it consists of a coarse quartz sand or gravel derived through the decomposition of the underlying rock. But even on the plateau, as, for example, along the trail between Pleasant Bay and the Big Intervale at Aspy Bay, there may be found considerable deposits of drift. Further, the seemingly complete absence of a truly alpine flora, even on the higher summits, would point strongly toward glaciation. In the lowland, the Carboniferous formations everywhere are hidden by a mantle of glacial débris: in places along the coast, as at French River and

Pleasant Bay, there are sea bluffs, more than fifty feet high, composed entirely of glacial drift, while in some of the brook valleys, e. g., in that of Power Brook, there are accumulations of drift fully as deep. Glacial striae have been observed in several localities (Fletcher '85, p. 77H), but, owing to the rapidity with which most of the rocks crumble when exposed to the weather, such evidences of glaciation are rare.

The distribution of roads and settlements in northern Cape Breton has been determined largely by the character of the topography and of the soil. Along the east coast a road follows the shore from St. Ann's Bay to Cape North, with branches extending inland a short distance wherever intervales occur. From the head of the Big Intervale at Aspy Bay (Fig. 7), a rough trail crosses the plateau to Pleasant Bay, and leads thence southward over the mountains toward the mouth of the Cheticamp River, where, in conformity with the better character of the country, roads are again encountered. The southwestern part of the area mapped affords excellent farming and is well populated, but elsewhere the farms, for the most part, are confined to the intervales and to the low coastal strip. The agricultural possibilities of many of the tracts which have been brought under cultivation would scarcely have been appreciated by any save the Scotch Highlanders, whose descendants constitute the larger proportion of the population of the country. At several points along the coast, as at Cheticamp and Neil's Harbor, the fishing industry supports considerable communities. The mountainous interior of northern Cape Breton is a wilderness, uninhabited and roadless, difficult to travel and little known, seldom visited except by trappers and hunters.

V. CLIMATE

In Table I are given the average temperature and precipitation records for twenty years at Sidney.[3] Although there are known to be certain discrepancies, in a general way these figures doubtless represent the meteorological conditions in northern Cape Breton. For purposes of comparison, climatic data for various

[3] Part of the climatic data here given has been supplied by Director R. F. Stupart of the Canadian Meteorological Service. The remainder has been secured from various sources.

selected stations in eastern Canada are briefly presented in Table II. Of the stations here listed, the first five are in the Maritime Provinces: Sidney, Halifax, and Yarmouth front on the ocean, and St. John on the Bay of Fundy; while Frederickton

TABLE I

Average Temperature and Precipitation Records for Twenty Years at Sydney, N. S.

Month	Degrees of Temperature, Fahrenheit					Precipitation	
	Mean Daily	Mean Daily Maximum	Mean Daily Minimum	Monthly Extremes		Total Amount (Inches)	Number Rainy Days (0.01 inch or more)
				Maximum	Minimum		
January...	23	31	15	57	−14	5.19	12
February..	21	30	13	59	−15	4.39	10
March....	28	36	20	58	−18	4.90	13
April.....	37	44	29	77	3	4.04	12
May.....	46	55	37	78	22	3.00	11
June.....	55	64	45	86	28	2.66	10
July.....	64	73	54	92	35	3.16	10
August...	63	72	54	88	36	3.03	11
September.	57	66	48	88	30	3.48	11
October...	48	56	40	77	25	4.11	13
November.	39	45	34	67	12	5.63	14
December.	30	36	24	58	0	5.92	14
Year.....	42	51	33	92	−18	49.51	11

TABLE II

Temperature and Precipitation Data for Various Stations in Eastern Canada

Station	Temperature (in Degrees Fahrenheit)				Precipitation	
	Normal Mean Daily for Hottest Month	Normal Mean Daily for Coldest Month	Average Extreme Maximum for Years 1907–1914	Average Extreme Minimum for Years 1907–1914	Normal Annual Amount (inches)	Per cent. Falling in Months October–March
Sydney, N. S.....	64	21	88	−10	49.51	61
Halifax, N. S.....	65	24	91	−10	56.81	57
Yarmouth, N. S....	61	27	78	1	51.94	55
St. John, N. B.....	61	19	80	−13	48.08	55
Frederickton, N. B.	66	13	92	−27	46.44	56
Quebec, Que.....	66	10	90	−24	41.10	49
Montreal, Que.....	69	13	91	−18	40.32	52
Port Arthur, Ont...	62	7	91	−32	23.22	29

lies inland, about fifty miles west of St. John. Of the three remaining stations, Quebec and Montreal are situated in southern Quebec, about 200 miles from the seacoast, and Port Arthur is located in western Ontario, on the north shore of Lake Superior. This latter station is introduced, partly because it exemplifies the relatively continental as compared with the relatively maritime type of climate, and partly because of its proximity to Isle Royale, the scene of Cooper's investigations ('13).

Northern Cape Breton may be said to possess a cool-temperate, maritime climate. In the following paragraphs the general climatic features of this region are briefly summarized, and attention is called to certain differences between the climate of the plateau and that of the lowland.

a. GENERAL CLIMATIC FEATURES OF NORTHERN CAPE BRETON

Temperature.—As compared with regions which are not in close proximity to the ocean, the temperature here is more equable. Some idea of the difference is suggested by the figures in Table II. It will be seen here, for example, that the disparity between the mean temperatures for the warmest and coldest months of the year at Sydney is only 43°, as compared with 53° at Fredericton, and 55° or more at Quebec, Montreal, and Port Arthur. This same dissimilarity between coastal and interior regions is brought out by comparing the extreme maximum and minimum temperatures for the year at the various stations. The winters in northern Cape Breton are long and cold, but extremes of temperature such as prevail toward the interior of the continent are seldom experienced (see TABLE II). Spring is sometimes very late in arriving, owing partly to the quantity of drift ice in the adjacent waters. The summers are short and cool, but there are only three months in the year when the mean monthly minimum at Sydney is *lower* than 32°. This latter fact is in marked contrast to the conditions at Port Arthur (see Cooper '13, p. 8), where the mean monthly minimum is *higher* than 32° only during June, July, and August.

Precipitation.—In common with other regions along the Atlantic Coast the precipitation in northern Cape Breton is copious and is well distributed over the entire year. More than 60 per cent. of it comes during the period of comparative vegetative inactivity, a condition quite the reverse of what prevails in

the interior of the continent (see TABLE II), and also to that which characterizes the Atlantic Coast farther south (at Charleston, S. C., for example, out of an annual precipitation of 52.07 inches, only 39 per cent. falls during the period from October to March). Snowfall in winter is usually heavy and, on account of the backward spring, the snow commonly remains on the ground for a long time. Fletcher ('85, p. 86) notes that in the middle of June, 1881, patches of snow still lingered in sheltered situations, while in 1914 and 1915 the writer observed snow-ice as late as August at the foot of an open north-facing slope along the Barrasois River.

Humidity.—Fogs are more or less prevalent at all seasons, and even in clear summer weather the humidity of the atmosphere is quite perceptible. Figures regarding the rate of evaporation throughout the growing season are not available, but during the summer of 1915, for a period of nearly three weeks, the writer operated a series of porous cup atmometers in various habitats, and the results obtained from those set up in the open near the coast are given in TABLE III. The readings in the first four columns of this table were taken near the Barrasois River. The "Shore" station was situated on an exposed, east-facing hillside,

TABLE III

RATE OF EVAPORATION ALONG THE COAST OF NORTHERN CAPE BRETON DURING THE SUMMER OF 1915, AS INDICATED BY THE POROUS CUP ATMOMETER

Station	July 22–July 27	July 27–August 3	August 3–August 7	Daily Average	August 20–August 23
Shore.....	28.8 cc.	45 cc.	84.2 cc.	9.8 cc.	79.2 cc.
Intervale.....	39.4 cc.	53.3 cc.	91.9 cc.	11.5 cc.	(3½ days)

about a quarter of a mile from the seacoast. The "Intervale" station was located in a similar site about five miles from the shore, at the head of a broad open valley. The figures in the fifth column were obtained from an instrument set up on a low hill at Ingonish, within a stone's throw of the open ocean. The average daily rate of evaporation for the entire period at the shore stations was about 12.2 cc. During the period of July 22–August 3 there was considerable rain and fog, while during the

periods August 3–7, 20–23, the weather was uniformly clear. For these latter periods the daily rate of evaporation at the shore stations averaged 21.7 cc. The evaporation rate at the intervale station, it will be noted, averaged slightly higher than that at the shore station.

b. CLIMATE OF THE INTERIOR PLATEAU COMPARED WITH THAT OF THE COAST

Temperature.—Aside from a few figures obtained by the writer, few accurate comparative data are available regarding climatic conditions on the plateau, although various interesting observations have been supplied by trappers. In August, 1915, two recording thermometers were set up in the open, one near the shore at Ingonish, the other in the barrens about fifteen miles west of Ingonish (elevation perhaps 1,200 feet). During the writer's stay in the barrens daily readings were made from these instruments, and subsequently readings were taken at intervals of a few days by a competent guide, who made trips into the barrens for this purpose. The readings were continued at each station until a temperature of 32° or lower had been recorded. The figures given in TABLE IV and covering part of this period

TABLE IV

MAXIMUM AND MINIMUM TEMPERATURES (°F.) IN THE INTERIOR AND ALONG THE COAST OF NORTHERN CAPE BRETON; AUGUST 18–23, 1915

	Mean Daily Maximum	Mean Daily Minimum	Mean Daily Range	Extreme Maximum	Extreme Minimum
Barrens.....	74°	48°	26°	80°	43°
Ingonish.....	71°	56°	15°	75°	52°

are suggestive, if nothing more. It is of interest to note that the daily maximum temperature in summer is frequently higher, and the daily minimum invariably lower, while the average daily range of temperature is perceptibly greater on the plateau than along the coast. Observations recorded for nine days show the average daily minimum to range from six to ten degrees lower on the plateau than along the coast, and the average daily maximum about one degree lower. For the barrens station the first freezing temperature was recorded on

September 8 (30°), eighteen days earlier than at the Ingonish station (September 26: 31°). There is little doubt that on the plateau, during some seasons, the temperature falls below freezing during every month of the year. And not only are the daily minimum temperatures here during the growing season lower than in the lowland, but the growing season is considerably (probably from six weeks to two months) shorter here than there.

Precipitation, Evaporation and Wind.—No exact observations have been made regarding precipitation on the plateau, but from the writer's experience and from numerous inquiries it can be stated with certainty that during summer the rainfall is somewhat heavier here than along the coast. The evaporating power of the air in *clear* weather, at least during the summer, is apparently greater than along the coast. This observation is deduced from atmometer readings, taken for the brief period of three and a half clear days in August, when an instrument on the barrens indicated a daily evaporation rate of 28.4 cc., as compared with 22.6 cc. near the shore at Ingonish. But, on the whole, the humidity of the atmosphere is greater on the plateau than on the lowland. This is due to the prevalence here of fogs. During dull weather the clouds hang low, covering the slopes and summits of the mountains above an elevation of seven or eight hundred feet, sometimes for days at a time. Even though it may not actually rain, everything is saturated with moisture. The higher rate of evaporation during clear weather is correlated with the heavy winds which sweep across the plateau at all seasons. So effective are these that a wet, spongy bed of cladonias may become dry and brittle within a few hours. The effect of wind on the vegetation, as seen in the barrens, is even more pronounced in winter than during the growing season. This will be discussed later in connection with the vegetation of the barrens.

VI. ECOLOGICAL CLASSIFICATION OF MATERIAL; NOMENCLATURE

The ecological classification adopted in the present paper has already been described in considerable detail elsewhere (Nichols '17), and need be only briefly outlined here. The fundamental unit of vegetation from the standpoint of physiographic ecology

is the *plant association:* any group or community of plants, taken in its entirety, which occupies a common habitat. Associations which are correlated with a common type of habitat and which are ecologically equivalent to one another may be referred to a common *association-type.* The culminating member of any specific successional series is termed an *edaphic climax association.* In favorable situations this edaphic climax coincides with the *regional climax association-type:* the most mesophytic type of vegetation of which the climate of the region permits the development on ordinary uplands. But, in unfavorable situations, the edaphic climax may be represented by an association which is less mesophytic than the regional climax type.

Parenthetically, it may be remarked that while emphasis is usually placed, as above, on the relatively high degree of *mesophytism* which characterizes the regional climax association-type, it is quite likely that this conception, while in general doubtless holding true, should be altered somewhat. In the lowland of northern Cape Breton, for example, a coniferous forest association on ordinary uplands represents either a temporary stage, destined to give way to deciduous forest, or else an edaphic climax (see definition below); yet not infrequently, in so far as their relative mesophytism is concerned, such forests seem quite on a par with forests of the regional climax type. The differentiating factors concerned in this particular case are suggested in the writer's discussion of the ecological relations of the balsam fir (p. 285).

In any unit area where more than one association is represented, the associations, taken collectively, constitute an *association-complex.* Within any specific geographic region the associations are grouped naturally into a series of more or less definite complexes with reference to the physiographic features of the region, i. e., with reference to topography and soil. Any association-complex which is thus related to a specific physiographic unit area constitutes an *edaphic formation.* Edaphic formations which are correlated with a common type of physiographic unit area may be referred to a common *edaphic formation-type.* The edaphic formations of any unit area, where more than one is present, taken collectively, constitute an *edaphic formation-complex.* The edaphic formation-complex

of any climatic region constitutes a *climatic formation.* To sum up: the association is a unit determined by habitat; the edaphic formation is a unit determined by physiography—a unit of a higher order than the association; while the climatic formation similarly is a unit determined by climate—a unit of a still higher rank than either of the preceding.

In the account of the ecological relations of the vegetation of northern Cape Breton which follows, the two climatic formations here represented are discussed separately. The scheme followed in classifying the innumerable associations which, taken collectively, comprise the vegetation of the respective regions concerned is partially outlined in the table of contents, which may be looked upon as in the nature of an analytical key. For the benefit of readers to whom the writer's paper on classification may not be available, a few further remarks regarding the system on which this synopsis is built up may be added.

First of all, taking into account their successful relations to one another and their distribution with reference to specific physiographic unit areas, the various individual units of vegetation, the associations, have been assembled into definite association-complexes. An individual association-complex, as thus defined, constitutes an edaphic formation. For obvious reasons, however, the various individual associations have been treated collectively, as association-types, and, similarly, emphasis has been laid on the edaphic formation-types rather than on the individual formations (see definitions above). Proceeding further, the edaphic formations (and formation-types) of the region have been divided primarily with reference to the water relations of the areas which they occupy into two successional series: formations of the xerarch series, and formations of the hydrarch series.[4] Under each of these two heads, in the case of the region of deciduous forests, it has seemed desirable to distinguish between primary and secondary formations, the latter embracing formations in which the vegetation has been modified

[4] The term xerarch, to quote Cooper ('13, p. 11), "is applied to those successions which, having their origin in xerophytic habitats, such as rock shores, beaches, and cliffs, become more and more mesophytic in their successive stages; . . . [the term hydrarch] to those which, originating in hydrophytic habitats, such as lakes and ponds, also progress toward mesophytism."

by cultivation, lumbering, or fire. The formations of the xerarch and hydrarch series respectively are further subdivided with reference to the general topographic features of the region, these being considered from the standpoint of their relationship to one another through physiographic development. Thus, among the formations of the xerarch series, three groups of formation-types are distinguished: the formation-types, respectively, of ordinary uplands, of uplands along streams, and of uplands along the seacoast. In the same way, the formation-types of the hydrarch series fall more or less naturally into three groups: the formation-types of lakes, ponds and swamps inland, the formation-types in and along rivers and streams, and the formation-types along the seacoast. The classification of formation-types primarily on the basis of water supply is open to certain objections, but so also is their classification primarily on the basis of physiography, a method which might perhaps equally well have been followed.

In discussing the vegetation of each region, the regional climax association-type is taken up first, since an understanding of this, representing as it does the highest degree of mesophytism permitted by the climate—the climatic indicator, so to speak, is prerequisite to an adequate interpretation of subordinate association-types and of successional relations. The edaphic formation-complex of the region, which of course includes all the edaphic formations and formation-types, with the associations and association-types which comprise them, including the regional climax association-type, is then considered, after the manner outlined in the preceding paragraph.

In matters of nomenclature the author, in general, has followed the seventh edition of Gray's Manual ('08), with the emendations of Robinson and Fernald ('09), for the vascular plants, his own papers on the bryophytes of Cape Breton ('16[a], '18) for the mosses and liverworts, and Fink's Lichens of Minnesota ('10) for the lichens. In the case of the vascular plants, changes in nomenclature since the publication of the Manual for the most part have been neglected. Only in exceptional cases are authorities cited for the names used. In cases where a plant is referred to by its common name, the scientific name is usually given only in connection with its first mention in the text.

THE DECIDUOUS FOREST CLIMATIC FORMATION IN NORTHERN CAPE BRETON

I. THE REGIONAL CLIMAX ASSOCIATION-TYPE: THE CLIMAX FOREST

Present and past distribution of the climax forest.—To one visiting northern Cape Breton at the present day the prevailing aspect of the lowland forests (FIGS. 9, 39, 42, etc.) appears to

FIGURE 9.—Second growth woodlands of balsam fir and white spruce; Barrasois.

be coniferous: white spruce and balsam fir predominate on every side. But practically all of these forests are secondary in their origin. Although settlements in this region for the most part date back scarcely one hundred years, during this short period the greater part of the country has been either cut or burned over, and much of it, at one time or another, has been cultivated or used for pasturage. In view of the widespread destruction or modification of the original vegetation, the nature of the primeval forests must be judged very largely from the

scattered vestiges which for one reason or another have remained intact. From the study of many such fragments, together with certain little modified tracts of second growth forest, it has become unmistakably evident that in former times a very large

FIGURE 10.—Primeval forest of the regional climax type, on lower slopes of mountains along Northeast Margaree River; mostly beech and maple; balsam fir well represented in undergrowth and to some extent in mature stand.

portion of this area was clothed with forests in which the predominant trees were deciduous. It is certain (and this conclusion is confirmed by statements of many of the older settlers) that forests of this sort were developed in practically all edaphically favorable situations; they were by no means local in their occurrence, but rather of very general distribution. The

structure of these regional climax forests is considered in brief detail in the following paragraphs. Their general aspect is illustrated by FIGS. 10–12.

The trees of the climax forest.—The nature of the individual associations which comprise the climax association-complex of the lowland varies considerably. In some places the forest is made up wholly of deciduous trees, but more commonly it consists of a mixture of deciduous and evergreen species. The various trees which may enter into the composition of the forest are named below, together with remarks as to their frequency and ecological importance. (1) Deciduous Species:—Beech (*Fagus grandifolia*) is almost invariably the predominant species, in some cases including fully 65 per cent. of the mature trees. Sugar Maple (*Acer saccharum*) is always present and usually ranks second in abundance to the beech. Yellow Birch (*Betula lutea*) is likewise omnipresent and sometimes outnumbers the sugar maple. Red Maple (*Acer rubrum*) is rarely absent, and frequently occupies a prominent position in the forest. Paper Birch (*Betula alba papyrifera*) ordinarily grows scattered through the forest. In some stands these five species are the only large-sized trees represented in the mature growth. The northern Red Oak (*Quercus rubra ambigua*) is widely distributed, and in some localities, as at Pleasant Bay and in the vicinity of Cape North, is an important constituent; but in most places it is only sparingly represented, and often it is absent. White Ash (*Fraxinus americana*) is not uncommon in many low intervale forests, but elsewhere it is comparatively rare. Balsam Poplar (*Populus balsamifera*) is occasionally encountered in virgin forests. (2) Evergreen Species (conifers):—Balsam fir (*Abies balsamea*), in the majority of cases, is a conspicuous, though not necessarily abundant, member of the forest, growing intermixed with the various deciduous species. Hemlock (*Tsuga canadensis*) is locally abundant and sometimes is the predominant tree; but often it is absent or represented only by scattered trees. White Pine (*Pinus Strobus*) is also an important constituent, locally, at any rate. It is particularly characteristic of the steep, well-drained, rocky slopes and ridges which flank many of the larger streams; but repeated cutting has thinned out this tree to a greater extent than any other single species. White Spruce (*Picea canadensis*) grows sprinkled here and there

through the forest, though seldom present in quantity. Black Spruce (*Picea mariana*) also is frequently represented by scattered specimens.

In the account which follows, for the sake of convenience, forests of the usual climax type, predominantly deciduous but with a more or less pronounced admixture of evergreen trees, are frequently referred to simply as "deciduous forests."

FIGURE 11.—Primeval forest of the regional climax type, along Indian Brook; mostly beech, maple, and hemlock, with some yellow birch and balsam fir; dense undergrowth of yew.

Size of trees in climax forest.— The relatively large size attained by some of the trees in the primeval forests of northern Cape Breton is suggested by the following diameter measurements[5] which were noted for various species: beech, 25 inches; sugar maple, 36 inches; yellow birch, 42 inches; red maple, 18 inches; paper birch, about 3 feet; red oak, 35 inches; white ash, 24 inches; balsam poplar, about 2 feet; balsam fir, 16 inches; hemlock, 30 inches; white pine, about 30 inches; white spruce, 26 inches; black spruce, about 12 inches.

[5] Diameter measurements of trees were taken at breast height.

Woody undergrowth in the climax forest.—Two small trees, the mountain maple (*Acer spicatum*) and the moosewood (*Acer pennsylvanicum*), are usually conspicuous in the undergrowth. The latter species sometimes attains a diameter of nearly a foot, but, in the forest, both are usually little more than shrubs. The mountain ash (*Pyrus americana*) is not infrequent, but is more characteristic of the evergreen coniferous climax forest of the

FIGURE 12.—Primeval forest of the regional climax type, at Tarbet, along the Barrasois; mostly beech, maple, and yellow birch; balsam fir abundant in undergrowth but absent from mature stand.

highland. Of the shrubs, the yew (*Taxus canadensis*) is the most characteristic species: usually this is common, and frequently it forms a dense tangle which excludes other plants in much the same way that the mountain laurel (*Kalmia latifolia*) does in the woods of southern New England. Sometimes, however, the yew is entirely absent over considerable areas. The northern hazel-nut (*Corylus rostrata*) occupies a position in the forest here somewhat parallel to that held by the witch hazel in woods farther south. A few other shrubs are ordinarily represented by scattered specimens, namely: fly honeysuckle

(*Lonicera canadensis*), withe-rod (*Viburnum cassinoides*), gooseberry (*Ribes lacustre*), dogberry (*Cornus alternifolia*), and red-berried elder (*Sambucus racemosa*). The hobble bush (*Viburnum alnifolium*), one of the most representative shrubs of the climax forest throughout much of the transition region, is very local in northern Cape Breton.

The herbaceous vascular plants of the climax forest.—The following list includes the more characteristic ferns and herbaceous seed plants of the regional climax forest.[6]

Phegopteris polypodioides	*cc*	*Epipactis tesselata*	*co*
Polystichum acrostichoides	*fc*	*Coralorrhiza maculata*	*co*
Polystichum Braunii	*lf*	*Actaea rubra*	*cf*
Aspidium noveboracense	*fc*	*Actaea alba*	*lr*
Aspidium Filix-mas	*lc*	*Oxalis Acetosella*	*cf*
Aspidium marginale	*lc*	*Viola canadensis*	*of*
Aspidium spinulosum var.	*cc*	*Viola incognita*	*cf*
Botrychium virginianum	*of*	*Aralia nudicaulis*	*cc*
Lycopodium lucidulum	*cc*	*Sanicula marilandica*	*of*
Carex arctata	*fo*	*Pyrola elliptica*	*cf*
Clintonia borealis	*cc*	*Monotropa uniflora*	*cf*
Smilacina racemosa	*ff*	*Monotropa Hypopitys*	*fo*
Maianthemum canadense	*cc*	*Trientalis americana*	*cc*
Streptopus roseus	*cc*	*Epifagus virginiana*	*lf*
Medeola virginiana	*ff*	*Mitchella repens*	*cf*
Trillium cernuum	*of*	*Linnaea borealis americana*	*of*
Habenaria orbiculata	*co*	*Aster acuminatus*	*cc*
Epipactis decipiens	*co*		

Several species have been omitted from this list which are characteristic of low-lying intervale forests, but not of climax forests in general. These will be noted later.

[6] In this and in several subsequent lists of the plants characteristic of the climax association-type, an attempt has been made to indicate both their general prevalence and their relative abundance when present. The following symbols are used: *c* = *common*; *f* = *frequent*; *o* = *occasional*; *r* = *rare*; *l* = *local*. In each case two symbols are given, the first indicating merely the frequentness with which the species is represented (i. e., is either present or absent) in associations of the climax type, the second indicating its relative abundance, when present, in the individual association. For various reasons it has not seemed feasible to carry out this scheme in connection with other association-types.

The bryophytes and lichens of the climax forest.—Corticolous mosses and liverworts form a striking feature of these forests. Loose mats of *Neckera* and *Leucodon, Porella* and *Frullania* often literally plaster the trunks of maple and other trees; *Ulota* grows in scattered, compact tufts, particularly on trunks of beech; while two lichens, *Sticta pulmonaria* and *Parmelia saxatilis,* are of very common occurrence. Tree bases, logs and rocks also are usually hidden by masses of *Bazzania, Anomodon* and various Hypnaceae. A list of some of the more conspicuous species follows:

Bazzania trilobata	*cc*	*Thuidium delicatulum*	*cf*
Ptilidium ciliare	*cf*	*Brachythecium reflexum*	*cf*
Porella platyphylloidea	*cc*	*Rhytidiadelphus loreus*	*fc*
Frullania Tamarisci	*cc*	*Rhytidiadelphus triquetrus*	*fo*
Dicranum longifolium	*ff*	*Hylocomium splendens*	*cf*
Dicranum scoparium	*cc*	*Hylocomium umbratum*	*cf*
Ulota ulophylla	*cc*	*Ptilium crista-castrensis*	*co*
Mnium cuspidatum	*cc*	*Stereodon cupressiformis*	*cf*
Leucodon sciuroides	*cf*	*Heterophyllon Haldanianum*	*cf*
Neckera pennata	*cc*	*Hypnum Schreberi*	*cf*
Heterocladium squarrosulum	*cf*	*Webera sessilis*	*fo*
Anomodon attenuatus	*ff*	*Polytrichum ohioense*	*cf*
Leskeella nervosa	*co*		

But while mosses and liverworts are present in profusion in these deciduous climax forests, it is important to note that they develop luxuriantly for the most part only on substrata which are elevated above the general level of the forest floor. On the forest floor itself the bryophytes usually are sparsely represented and they may be totally absent over considerable areas. This is in striking contrast to the conditions which prevail in the evergreen coniferous climax forests of the highland, where the ground is almost always carpeted by a rich growth of bryophytes. Various explanations for this dissimilarity have been considered by the author. At first it seemed that it might be due to differences in soil acidity, but all the forest soils tested were found to be more or less acid to litmus. Similarly, differences in light fail to afford an adequate explanation. The conclusion has finally been reached that the scarcity of mosses and liverworts on the forest floor in deciduous forests is correlated in large measure

with the deciduous habit. Every year the ground is covered with a more or less continuous blanket of fallen leaves; mosses and liverworts may be buried alive, so to speak, and repeated instances have been observed where without question they have been partially or wholly exterminated in this way. In a general way it may be stated that in the climax forests of northern Cape Breton the abundance of bryophytes is inversely proportional to the abundance of deciduous trees.

Reproduction of the climax trees.—In the normal course of events, the future character of any forest is determined in large measure by the present character of the immature trees. The nature of the rising generation may be said to furnish a criterion of permanency. A permanent forest is one which is able to perpetuate itself. It is therefore a significant fact that in the primeval forests of this region the composition of the younger generation of trees, at least so far as the dominant species are concerned, is essentially the same as that of the mature stand. Beech, sugar maple, birch, and red maple almost everywhere exhibit good reproduction underneath the forest canopy. The same is true, more locally, of the oak and hemlock, and to a less extent of the ash and white pine. Reproduction in the balsam fir is discussed in subsequent paragraphs. Young trees of paper birch and white spruce are seldom found, and it seems probable that, in general, they either represent relicts of a more primitive type of forest, or that they are able to establish themselves only under the more favorable light relations which are occasionally created by gaps in the forest canopy overhead.

The ecological relations of the balsam fir in the climax forest.—The balsam fir may be regarded as the character tree of the northeastern evergreen coniferous climatic forest formation (in this connection, see especially Cooper '13, pp. 36–39). In parts of Cape Breton where this climax formation holds sway, the balsam far outnumbers all other trees. In the competition for supremacy between the deciduous and the evergreen coniferous climax forest-types, the balsam fir, in this region at any rate, is the last element of the more northern type of forest to disappear. For this reason, the ecological relations of this tree in the climax forests of the lowland have been given considerable attention, although it must be admitted that the observations have not been wholly conclusive.

Seldom, if ever, is a tract of climax forest encountered from which the balsam fir is wholly absent. Frequently, however, it is represented only in the younger growth. This latter condition is well brought out by TABLE V, which shows the relative

TABLE V

RELATIVE ABUNDANCE OF VARIOUS TREES IN TWO QUADRATS IN A HARDWOOD FOREST ALONG THE BARRASOIS RIVER[7]

Name of Species	Diameter Less than 2 Inches	Diameter 2–5 Inches	Diameter 5–10 Inches	Diameter More than 10 Inches
Fagus grandifolia.....	55	5	7	3
Acer saccharum.....	33	0	2	2
Betula lutea.....	2	1	1	2
Acer rubrum.....	3	0	0	1
Abies balsamea.....	23	0	0	0

[7] Quadrat 32.8 feet (ten meters) square. Figures for the two quadrats are added. No trees less than one foot high counted.

abundance of various trees on two quadrats in a hardwood forest along the Barrasois River (FIG. 12). The most interesting facts to be deduced from this table are: (1) that, of the trees less than five inches in diameter and more than one foot high, balsam fir includes 18.5 per cent. (as compared with beech, 50 per cent.; sugar maple, 26.6 per cent.; yellow birch, 2.4 per cent.; red maple, 2.4 per cent.); while (2), of the trees more than five inches in diameter, none at all are balsam (as compared with beech, 55.5 per cent.; sugar maple, 22.2 per cent.; yellow birch, 16.6 per cent.; red maple, 5.5 per cent.). In the mature stand, taken as a whole, it was estimated that beech includes fully 65 per cent. of the trees, sugar maple and yellow birch each about 15 per cent., red maple and paper birch together about 5 per cent. So far as observations extended, no mature balsam fir whatever is present, the largest living specimen noted being about fifteen feet high; but several dead, standing or fallen, trunks having a diameter of about eight inches were found. The larger living specimens average six or eight feet in height, and are greatly suppressed, many of them showing twenty-five or more annual rings.

The conditions noted in this tract of forest are essentially similar to those which prevail in many other areas: balsam fir

is abundantly represented in the younger generation, but is virtually absent from among the mature trees. The absence of mature balsam, however, is far from being the rule. In the majority of cases it grows along with the more southern climax trees, forming an important constituent of the stand, and contributing to the formation of the mixed deciduous-evergreen forest which is the prevailing climax type throughout the lowlands. In competition with the deciduous climax trees, however, the balsam seldom retains a position of dominance, and occasional tracts of primeval forest are encountered in which not only all the mature trees, but practically all the younger ones as well, are hardwoods or hemlock. Forests of this sort are essentially similar to the type which formerly prevailed in many parts of southern New England (see Nichols '13).

In view of the facts set forth above, the query naturally arises: Assuming the climatic conditions to be equally favorable to all the species concerned, why is it that, in competition with maple, beech, hemlock, and the other species which characterize the deciduous climax forest, the balsam fir is unable to hold its own? For obvious reasons this is an important question, and one to which various answers may be suggested.

(1) The relative tolerance of shade exhibited by the various species concerned, at first thought, seems to afford the most likely explanation. Beech, sugar maple, and hemlock are notably tolerant species: they are capable of successful reproduction in their own shade. Regarding the tolerance of the balsam fir there seems to be a discrepancy of opinion. According to Cooper ('13, pp. 17–22, 42, 43), the balsam demands abundant light for successful reproduction: "Later in life the young trees can endure severe shading, but for a successful start abundant light seems to be a necessity." Zon ('14, p. 39), on the other hand, states that, "For the first five or six years of its life, balsam will grow in dense shade, but as it develops it demands more and more light." In northern Cape Breton, the sparsity of balsam seedlings and young trees in many hardwood tracts might well harmonize with Cooper's conclusions, were it not for the fact that in other equally shady forests the young balsam growth is quite abundant. In this connection the observation of Moore ('17, p. 157), made on Mount Desert Island, that, "Under many spruce stands which have reached about middle

age, the fir reproduction is nearly all composed of large seedlings approximately 1–3 feet in height; young seedlings are scarce," is of interest. As indicated above, parallel conditions have frequently been observed in the lowland climax forests of northern Cape Breton. Moore suggests that, "In these cases it appears that the fir came in profusely under a set of environmental conditions different from the present ones . . . . One of them may have been stronger light than at present. Indications of this were found in the fact that some of these cases of fir reproduction occur in stands which were formerly more open than they are now." In one striking case of this sort, observed by the writer, the abundance of young balsam in a primeval hardwood forest is certainly correlated with the occurrence, about fifteen years ago, of a fire which, while it was not sufficiently severe to seriously injure the larger trees, must have resulted temporarily in a considerably increased illumination of the forest floor. Certain it is that the balsam reproduces best and grows most vigorously in well-lighted situations, and there seems to be little question that it is less tolerant of shade than sugar maple, beech, and hemlock. Nevertheless, repeated observations have led to the conclusion that at any rate tolerance alone, even in the broadest interpretation of the term (see Burns '16, pp. 3, 4, 22), cannot be regarded as the cause for the elimination of the balsam.

(2) It has been suggested by Murphy ('17) that the burial of the seeds of the spruce by a mulch of hardwood leaves may be a very important factor in the suppression of this tree in competition with deciduous trees. That the yearly accumulation of leaf litter on the floor of a deciduous forest is, in a somewhat similar manner, responsible for the poor development of the bryophytic ground cover, was a conclusion already arrived at by the writer (see page 284); and it seems not impossible that this may also be a factor of some significance as affecting the reproduction of the balsam fir.

(3) In the opinion of the writer, however, *longevity*, in the last analysis, is the critical factor which enables the maple, beech, hemlock and the associated climax trees of the deciduous forest climatic formation of eastern North America to win out in competition with the balsam fir. In this connection, the behavior of the hemlock, as studied in the primeval forests of north-

western Connecticut (see Nichols, '13), is enlightening. The hemlock is capable of growing in a suppressed condition under the shade of other trees for more than a century. A tree which has been thus suppressed may have attained at the end of a hundred years a diameter of perhaps six or eight inches and may have grown well up into the forest canopy overhead. With the improvement of light conditions, which may be accomplished either through its own upward growth or through the downfall of contiguous trees, such a tree grows vigorously, and may attain an age of more than 300 years, with a diameter of more than four and a height of more than a hundred feet, before its death is brought about through disease, wind, or other agency. What is said of the hemlock applies also to the sugar maple and beech, although these trees are perhaps more susceptible to disease than the hemlock. The behavior of the balsam fir is in marked contrast. Although, like the hemlock, the balsam is able to grow for many years in fairly dense shade, it is handicapped by its susceptibility to fungus diseases, largely in consequence of which its lease on life is limited. At the age of a hundred years, a hemlock, even if it has been growing suppressed all this time, will usually have a sound, healthy trunk. In northern Cape Breton, at any rate, the balsam fir, even under favorable conditions, seldom reaches the age of seventy years without having become infected by heart rot,[8] and by the time it has rounded the century mark its trunk usually has become badly rotted within. In addition to the "ground rot," which, in conjunction with the brittleness of the wood, renders the tree liable to windfall (Fig. 13), the balsam fir, when growing in a suppressed condition under hardwoods, is likely to be affected by "top rot," which may cause it to die back from the top. Like the hemlock, however, a balsam may ultimately find an opening in the forest canopy overhead. But by

[8] According to Zon ('14), two species of fungi are concerned: *Trametes Pini* (Brot.) Fr. and *Polyporus Schweinitzii* Fr., which may cause either "ground rot" or "top rot." According to the observations of Dr. G. P. Clinton in the western Adirondacks, and of the writer in northwestern Maine and northern Cape Breton, in these regions heart-rot in the balsam fir seems to be attributable to still another fungus, *Fomes pinicola* Fr., a species which Duggar ('09, p. 467) has also mentioned as one which causes disease in the balsam.

this time it is an old tree. For, while the hemlock at a hundred years is still comparatively young, the balsam is already a veteran, since (at least in northern Cape Breton) it seldom lives to be more than 125 years old.

To sum up, if it is assumed that the climatic conditions are equally favorable to all the species concerned, the apparent inability of the balsam fir to compete successfully with the species which characterize the deciduous climax forest formation

FIGURE 13.—Wind-felled balsam fir; Adirondack Mountains, New York. The specimen in the background shows the manner in which the trunk commonly splinters.

can be attributed in large part to its shorter tenure of life, coupled with which are its greater susceptibility to fungus diseases and its less pronounced tolerance of shade. That the climate in this region is favorable to the deciduous climax trees is attested by their vigorous growth and the large size which they commonly attain. That it is favorable to the balsam fir is manifest from the manner in which this tree thrives wherever there is freedom from competition. It should be added that, considering the transition region in its entirety, account must also be taken of climate. Climatic factors without doubt have been

of great importance during the northward migration of the deciduous climax trees which has ensued in post-glacial time (see especially Adams '02), and there is little question that in parts of the transition region farther south, where balsam is absent or restricted in its distribution, such factors are still of large significance.

General features of transition climax forests in northern Cape Breton and elsewhere.—The trees which characterize forests of the climax type in the lowland of northern Cape Breton may be divided into four groups, as follows: (*A*) Deciduous species, such as the beech and sugar maple, whose center of distribution lies south of the transition region; (*B*) Deciduous species, notably the yellow birch, whose center of distribution lies within the transition region; (*C*) Evergreen species, notably the hemlock, whose center of distribution lies within the transition region; and (*D*) Evergreen species, such as the balsam fir and white spruce, whose center of distribution lies north of the transition region. To these might perhaps be added a fifth group: (*E*) Deciduous species, such as the paper birch and the balsam poplar, whose center of distribution lies north of the transition region.

It has been intimated in earlier paragraphs that the relative abundance of the different climax trees is subject to considerable local variation. By way of summary, it may be stated that in forests of the regional climax type the trees of group *A* commonly predominate, though sometimes they are outnumbered by those of group *C*. The yellow birch, representing group *B*, is practically always present, varying greatly in abundance, usually common though seldom predominant (but see in this connection p. 387). The trees of group *D* are seldom completely absent: usually they occupy a prominent, but rarely a predominant, position in the forest. The trees of group *E* are commonly represented, but always as a minor element in the forest: frequently they are missing altogether.

While the above observations are made primarily with reference to conditions in northern Cape Breton, they are capable of much wider application. Throughout much of the vast expanse in eastern North America which is embraced by the transition region, the five groups of trees specified in the preceding paragraph are represented. Broadly speaking, throughout this area

the nature of the regional climax forests is essentially similar, in so far as their ecological aspect is concerned; but, just as in Cape Breton, there is considerable local variation in their composition—in the presence or absence of certain species and in their relative abundance when present. Leaving out of consideration the species of the fifth group, which occupy a relatively insignificant position here, it is possible to distinguish, with reference to the presence or absence in the forest of members of the first four groups outlined above, eleven different group-combinations of trees which may comprise an equal number of floristically different types of climax forest. Indicating the respective groups by letter, these various group-combinations are as follows: (1) *A-B;* (2) *A-B-C;* (3) *A-B-C-D;* (4) *A-B-D;* (5) *A-C;* (6) *A-C-D;* (7) *A-D;* (8) *B-C;* (9) *B-C-D;* (10) *B-D;* (11) *C-D.*

In sections of the country where all four groups of climax trees (*A, B, C, D*) are well represented, forests comprising any and each of these group-combinations may be encountered. As might be expected, however, while the trees of groups *B* and *C* are about equally well represented in forests throughout the transition region, those of group *A* are most generally represented southward, those of group *D* northward. It is along the southern borders of the transition region, in that part of the area where climatic conditions presumably are most favorable to the trees of group *A* (and least so for those of group *D*), and which these have occupied for the longest time that the first group-combination (*A-B:* the "northern hardwood" type of forest) is most extensively developed. Here the trees of group *D* tend to be localized in situations which are edaphically favorable: they develop best in areas which are somewhat swampy. Conversely, along the northern borders of the transition region, in that part of the area where climatic conditions presumably are less favorable for the deciduous species of group *A* (but more so for those of group *D*), or which, it may be, these species in their post-glacial migration have reached only in comparatively recent time, the trees of group *D* are commonly a conspicuous and even the predominant element in forests of the regional climax type. Here the trees of group *A* tend to be restricted to the better drained soils. It is important to note in this connection, however, that even along the northern

border of the transition region, as in Cape Breton, purely deciduous forests are by no means lacking, and that the trees of group *A* growing here compare quite favorably in size, vigor and ability to reproduce themselves with those growing in forests farther south. It is of further interest that along the southern border of the transition region the trees of group *D* may occupy a prominent position in climax forests: in one locality in northwestern Connecticut, for example, at an elevation of less than 2,000 feet, the black spruce is thriving on uplands, reproducing well, attaining a large size, and growing in association, not only with beech and maple, birch and hemlock, but with such species as chestnut (*Castanea dentata*) and mountain laurel.

Considerable interest attaches itself to the relative importance, in transition forests where the trees of group *D* are represented, of the balsam fir and black spruce. In northern Michigan (Whitford '01), Ontario (Howe & White '13), and elsewhere the balsam fir, as in Cape Breton, seems to be the predominant northern conifer. But in other localities the black spruce occupies the position of relative predominance. This seems to be true, to cite localities with which the author is personally familiar, in the western Adirondacks and in northwestern Maine. In the primeval forests about Big Moose (elevation about 2,000 feet), in the Adirondacks, for example, where it grows abundantly, in company with beech, sugar maple, yellow birch, and hemlock, the black spruce attains a diameter of more than three, and a height of more than 125 feet. Here, as in Maine, the balsam fir is present in the forest, but it is more characteristic of the "flats" and moister sites. As noted earlier, the black spruce is represented in the climax forests of the lowland in northern Cape Breton, but here it is infrequent and never reaches the size exhibited by the spruce in the Adirondacks.

In proceeding northward from the region of deciduous forests to that of coniferous forests (Fig. 1) there is a gradual transition from one type of forest to the other. Broadly speaking, however, due largely to the predominating influence of the deciduous element, forests of the regional climax type are essentially similar in their ecological aspect throughout the transition region. Various attempts have been made to define subdivisions of this region on the basis of vegetational dissimi-

larities, but while such subdivisions may be of floristic importance, their significance from the standpoint of ecological plant geography is at least open to question. Thus, it is doubtful whether the "Northern Mesophytic Evergreen Forest" region (characterized in the east by the presence, as the most common species, of white pine, hemlock, jack pine [*Pinus Banksiana*] and balsam fir), which Shreve ('17) maps as distinct from the "Northeastern Evergreen-Deciduous Transition Forest" region, should be so separated, since throughout this area, as elsewhere in the transition region, climax forests of the deciduous type are commonly encountered in situations which are edaphically suited to their development. Similarly, the "White Pine Region" of New England, as mapped by Hawley and Hawes ('12), while distinct from the standpoint of the forester, does not seem to be so from the standpoint of ecological plant geography. White pine is a frequent constituent of the climatic climax forest throughout the transition region; but, when growing in pure stands, it probably represents either a temporary association or else an edaphic climax. Not only does it appear unwarranted, from the standpoint of ecological plant geography, to recognize such subdivisions as distinct, but, as elsewhere suggested (p. 261), from this point of view the vegetation of the transition region itself is best regarded merely as a part of the great deciduous forest climatic formation of eastern North America.

II. THE EDAPHIC FORMATION-COMPLEX OF THE REGION

A. Primary Formations of the Xerarch Series

1. The Formation-types of Ordinary Uplands

a. INTRODUCTORY

In attempting to formulate the successful series which lead toward and, under favorable circumstances, culminate in the climax association-type of the region, there are three possible sources of evidence: (*1*) areas in which succession is actually taking place at the present time (or has taken place within comparatively recent times), as indicated more particularly by the presence of (*a*) relicts of more primitive associations, or (*b*) pioneers of more advanced associations than the present ones;

(*2*) areas in which, owing to the limiting influence of certain local factors, the succession has culminated in an edaphic climax which is less mesophytic than the regional climax association-type; and (*3*) areas which have been denuded of their original vegetation, and where secondary succession is taking place. Secondary successions are discussed in a separate section, but they obviously possess many points in common with primary successions.

Aside from the views of the regional climax forest (FIGS. 10–11), the primary formation-types of ordinary uplands are pictured only by FIGS. 14–16; but see in this connection the figures illustrating secondary formations (FIGS. 33–40).

b. THE ASSOCIATION-COMPLEXES OF ROCK OUTCROPS

Rock surface association-types.—The first forms of life to grow on a bare rock surface are usually the lichens. Commonly the crustose lichens appear first: species of *Buellia, Lecanora, Lecidia, Rhizocarpon,* etc. These are closely followed and often accompanied by foliose lichens: species of *Parmelia, Gyrophora,* etc. Associated with these may be the fruticose lichen, *Stereocaulon* sp., and certain lithophytic mosses, such as *Hedwigia ciliata* and *Grimmia apocarpa.* Where the rock slopes steeply, other plants may be entirely absent, owing to their inability to secure a foothold on the bare rock surface, and the succession may become arrested at this early stage.

But on gentle slopes the conditions are different, for here plants are able to maintain their positions even when entirely unattached to the substratum. Situations of this sort are favorable to the development of the fruticose lichens, notably species of *Cladonia* (e. g., *C. rangiferina, C. sylvatica*). These usually establish themselves first in shallow depressions of the rock surface, where moisture conditions are relatively favorable, and from here they may spread laterally in all directions until the surface of the rock becomes completely covered with a loose, essentially unattached mat of vegetation. In company here with the fruticose lichens very commonly grow certain mosses: these may include any of the species mentioned below as characteristic of crevices, but particularly *Racomitrium canescens* and species of *Polytrichum.*

Crevice association-types.—Contemporaneously with the rock surface "subsuccession" (Cooper '13, p. 118) occurs the crevice "subsuccession." In the crevices, and also, to some extent, in hollows of the rock surface, a soil is usually present, and this enables plants to grow which are unable to secure a foothold on a rock surface or to maintain themselves in such an environment. The pioneer crevice vegetation may include the fruticose lichens already mentioned as growing on rock surfaces. It may also include various mosses, such as *Ceratodon purpureus, Leucobryum glaucum, Dicranum scoparium* and *D. Bonjeanii,* and *Polytrichum piliferum.* But more important than these, in the light of subsequent events, are the ferns and seed plants. Of the ferns, *Pteris aquilina* is the most frequent crevice form, although *Polypodium vulgare* often grows here, in sheltered situations. Among the more important herbaceous seed plants which inhabit crevices may be cited *Potentilla tridentata,* which seldom grows anywhere else, *Deschampsia flexuosa* and *Danthonia spicata, Cornus canadensis,* and *Solidago bicolor.* Of the shrubby and semi-shrubby seed plants, *Vaccinium pennsylvanicum, V. canadense,* and *Gaultheria procumbens* are rarely absent, while *Vaccinium Vitis-Idaea* is especially characteristic of such habitats. Almost any of the trees to be mentioned presently as occurring on the heath mat may be found in crevices. In a sense there may appear to be a succession of growth forms in crevices, herbs preceding shrubs, etc., but succession of this sort, on the whole, is probably more apparent than real.

The heath association-type.—Up to a certain point, the rock surface and the crevice "subsuccessions" are distinct from one another. But with the formation of the lichen–moss mat over the rock surface, and the gradual accumulation of soil which accompanies the process, the two tend to merge into one. The various seed plants, particularly the shrubs, which hitherto have been largely confined to the crevices, become increasingly abundant over the rock surface, and ultimately there may arise what Cooper has aptly termed a "heath mat" ('13, p. 125). Here the ground is still covered by a mat of fruticose lichens and mosses, but these are no longer the dominant plants. As such they have been superseded by ferns and seed plants, whose roots tend to bind together the hitherto loose mat and to consolidate it

into a more or less compact turf. The predominant plants of the heath association-type are low shrubs, particularly Ericaceae. A list of species characteristic of this phase in the succession is given below.

Herbaceous Plants

Pteris aquilina	*Cornus canadensis*
Deschampsia flexuosa	*Melampyrum lineare*
Danthonia spicata	*Solidago bicolor*

Shrubby and Semi-shrubby Plants

Juniperus communis depressa	*Kalmia angustifolia*
Juniperus horizontalis	*Gaultheria procumbens*
Salix humilis	*Epigaea repens*
Alnus crispa	*Gaylussacia baccata*
Amelanchier sp.	*Vaccinium pennsylvanicum*
Empetrum nigrum	*Vaccinium canadense*
Nemopanthus mucronata	*Vaccinium Vitis-Idaea*
Rhododendron canadense	*Viburnum cassinoides*

Trees

Pinus Strobus	*Betula alba papyrifera*
Abies balsamea	*Pyrus americana*
Picea canadensis	*Prunus pennsylvanica*
Picea mariana	*Acer rubrum*

As a rule the dominant shrub of the heath mat is *Vaccinium pennsylvanicum*. But *Vaccinium canadense* may be equally abundant; while in some places the *Kalmia* forms an almost pure growth, or may grow mixed with *Rhododendron*. *Gaultheria* and *Epigaea* usually form a lower story of vegetation; and the same, locally, is true of *Vaccinium Vitis-Idaea*. *Empetrum* is particularly characteristic of exposed bluffs along the seacoast, and will be referred to again in that connection. Occasionally the grasses, *Danthonia spicata* and *Deschampsia flexuosa*, are dominant forms.

The coniferous forest association-type.—As already pointed out, trees may inhabit the crevices at an early stage in the succession. With the improvement of soil relations which results

from the mantling of the rock surface by a mat of vegetation, they cease to be confined to crevices and invade the areas between. At first few and scattered, they gradually increase in number and size and come to occupy the ground more completely. In the course of time, groups of trees in the more favorable situations form patches of embryonic woodland, and, as these spread and unite with one another, a more or less continuous forest may be evolved. Not infrequently trees come in so rapidly and in such force at the outset that the heath stage in the succession is virtually eliminated. The succession does not proceed with equal rapidity everywhere, even within a given physiographic unit area. For, owing to locally unfavorable edaphic conditions, succession in some situations lags behind that in others, with the result that there commonly arises a complex of associations, in which various stages in the developmental series are represented. This promiscuous intermingling of primitive and advanced associations becomes less pronounced as time goes on, but even in the midst of a climax forest there may be situations in which succession has never progressed beyond the rock face–crevice stage.

During the early phases of forest development, the white spruce commonly stands out as the predominant tree: the balsam fir, as a rule, is second in importance. Common associates in the rising forest are the paper birch, conspicuous by reason of its light color and large size; the black spruce, red maple, and mountain ash; and, less commonly, the white pine. As the forest matures, the relative importance of the two dominant trees undergoes certain changes, due very largely to the differing degree to which the two are tolerant of shade. The white spruce is a relatively intolerant species. Its seedlings thrive only in situations where there is abundant light. While it reproduces prolifically in the open, young trees are rarely encountered in the forest. The balsam fir, on the other hand, is relatively tolerant of shade. Like the white spruce, it reproduces best in well lighted situations, but unlike the white spruce its seedlings are also capable of thriving in moderate shade. The result is obvious. With the diminished illumination of the forest floor which accompanies the growth of the forest, there is a marked decrease in the rate of reproduction of the white spruce, while the balsam fir is much less affected. It follows that, as the

forest matures, the white spruce tends to become relatively less abundant, the balsam fir relatively more so.

Contemporaneously with the ever-increasing amount of shade produced by the canopy of foliage overhead, the vegetation of the forest floor also changes. The cladonias of the heath stage are largely superseded by bryophytes. Of the mosses, *Hypnum Schreberi* is the pioneer forest species and often appears on the heath mat well in advance of the forest itself. Along with this, but much less common, may grow *Rhytidiadelphus triquetrus.* As the shade and moisture conditions on the forest floor become more favorable, two relatively mesophytic mosses, *Hylocomium splendens* and *Ptilium crista-castrensis,* together with the liverwort, *Bazzania trilobata,* come to play an important part in the formation of the moss carpet, by which the ground sooner or later becomes almost completely covered over.[9] Of the shrubs and herbaceous vascular plants which are characteristic of the heath mat, certain species, such as *Pteris aquilina, Cornus canadensis, Epigaea repens, Vaccinium pennsylvanicum* and *V. canadense,* are equally characteristic of the coniferous forest, particularly during the early phases of its development. Coincident with the formation of the moss carpet, however, other species begin to appear which, while they may have been represented to some extent in the earlier stages of the succession, are more typical of the forest. The forerunners include *Maianthemum canadense, Aralia nudicaulis, Pyrola secunda, Trientalis americana, Chiogenes hispidula,* and *Linnaea borealis americana.* Later on, as the forest matures, these relatively xero-mesophytic forms are followed by other species which are more truly mesophytic, such as *Clintonia borealis, Coptis trifolia, Oxalis Acetosella, Moneses uniflora, Pyrola minor,* and *Aster acuminatus.*

Very often, during the early development of a coniferous forest there is a considerable period when the ground underneath the trees is almost barren of a plant cover. The probable explanation of this frequently observed phenomenon is suggested later in connection with the discussion of succession in abandoned pastures.

The edaphic climax association-type.—Theoretically, at least,

[9] Cooper ('11) has described a similar succession of lichens and mosses as accompanying the development of the climax forest on Isle Royale.

it is conceivable that even on a bare rock surface, through the gradual amelioration of the habitat by biotic factors, the succession of plant associations might progress still further, and that the vegetation here might ultimately attain the condition which characterizes the climax association-type of the region. But, as a matter of fact, on bare rock outcrops the succession seldom proceeds further than the coniferous forest stage. In other words, the coniferous forest can be regarded as representing the edaphic climax association-type of the rock outcrop successional series: it is a permanent association-type, though ordinarily less mesophytic than the regional climax association-type (in this connection, see Nichols '17, pp. 310-317). In its optimum development, the coniferous forest association-type of the rock outcrop series in the lowland may resemble very closely the climatic climax of the mountains, and indeed it may be quite as mesophytic as the regional climax type. Balsam fir is the predominant tree, while white spruce, paper birch, black spruce, white pine, red maple, yellow birch, and mountain ash are more or less abundantly represented. But, as has already been suggested, such may be the effect of the limiting edaphic factors that in many places the succession halts at a much earlier stage than this.

c. THE ASSOCIATION COMPLEXES OF GLACIAL DRIFT

Extensive outcrops of bare rock are seldom encountered in the lowland. The most widespread type of substratum here is glacial drift. The drift, to perhaps a greater degree than any other type of substratum, is well adapted to rapid colonization by plants. So favorable, indeed, were the original conditions here, and so rapidly has the succession of plant associations ensued, that the drift everywhere has long since become covered by forests. It is only where the original plant cover has been destroyed, either through the agency of stream or wave erosion, or else as the result of human activity or fire, that the earlier phases of the succession become apparent. The early stages of primary successional series on drift can be reconstructed by analogy, after a fashion, from the study of primary successions on other substrata and of secondary successions on the drift.

Coniferous forest locally an edaphic climax.—Disregarding for the present the earlier phases of the succession, suffice it to state that eventually there may arise on the drift a type of forest essen-

tially similar to what has been described above as constituting the ultimate phase in the rock outcrop series: a forest of balsam fir, white spruce, paper birch, etc. And it is of interest to note that, locally, such a forest may also constitute an edaphic climax, even on the drift. In the vicinity of Baddeck, for example, over most of the country succession has never progressed beyond the coniferous forest stage. This circumstance, without much question, is correlated with the heavy, clayey nature of the drift here, which has acted as a limiting factor to prevent the attainment of the regional climax. It is of further interest in this connection that around Baddeck, and in certain other localities where the soil is heavy, the tamarack (*Larix laricina*) is an important arborescent pioneer and a constituent of the coniferous forest. Throughout much of northern Cape Breton the tamarack is a rarity. Its ecological status will be referred to again in another connection (p. 412).

Development of the regional climax.—The yellow birch may be regarded as the forerunner of the deciduous trees which characterize the regional climax forests. This tree is usually represented in coniferous forests in the lowland, but there it occupies a position of prominence only in forests which are well advanced in their development. As the pioneer among the deciduous climax trees, it seems not unlikely that this tree, together with the red maple and paper birch, may help to pave the way for the beech and sugar maple. The effect on the moss carpet of the periodic accumulation of fallen leaves has been referred to elsewhere; and it is at least conceivable that the deciduous advance-guard in the coniferous forest, through the medium of leaf-fall, may in some way exert an ameliorating influence on the substratum, which facilitates the invasion of the forest by beech and sugar maple.

At any rate, wherever the soil conditions are favorable, coniferous forests are superseded by forests of the regional climax type. The trees of the coniferous forest stage in the succession may persist in varying degree, as earlier suggested, but they relinquish their position of dominance. All stages of transition may be found between forests of the coniferous type and those which are purely deciduous. During the transition from one type to another the undergrowth undergoes various changes. Certain species of the coniferous forest stage, such as *Coptis*

trifolia and *Chiogenes hispidula,* vanish almost completely; others, such as *Pteris aquilina, Cornus canadensis, Epigaea repens,* and *Moneses uniflora,* become much less common; while still other species, such as *Polystichum acrostichoides, Smilacina racemosa,* and *Sanicula marilandica,* which were poorly or not at all represented in the coniferous forest stage, come to occupy a more or less prominent position.

FIGURE 14.—Granitic talus of the prevailing type; north of Cheticamp.

d. THE ASSOCIATION-COMPLEXES OF TALUS

With reference to the size of the component rock fragments and the consequent degree of stability of the rock mass, talus slopes (FIG. 14) vary greatly. Two extreme types may be distinguished: the *Boulder Talus* and the *Gravel Slide.* Boulder talus consists essentially of large rock fragments (sometimes many feet in diameter), which tend to lodge together and interlock with one another on the slope in such a way as to produce a relatively stable rock mass. A gravel slide, on the other hand, consists primarily of fine, loose rock débris, which is not held together in any way but is constantly tending to slip further

down the slope, and thus produces a very unstable rock mass. Between the two extremes are all degrees of intergradation.

The association-types of boulder talus.—As in the rock outcrop series, two types of habitat are available to plants here, the rock surfaces and the crannies between the fragments. The surfaces of the boulders are usually overgrown with crustose and foliose lichens. Any of the rock face species previously cited may grow here. These, however, play little or no active part in the talus succession as a whole: the latter is instituted almost entirely by the plants which grow in the crannies. Here, through the further disintegration of the larger rock fragments, and also to some extent from other sources, a soil accumulates. Toward the base of a talus slope soil gathers faster and soil moisture is more abundant than higher up, so that as a rule succession progresses much more rapidly here than elsewhere on the slope. Very commonly the base of a talus slope will be clothed by a mesophytic forest while above there are only scattered trees and shrubs.

The shade and protection from exposure afforded by the blocks which surround the crannies create here conditions which are congenial to mesophytes as well as to many xerophytes. The pioneer plants may include various species of *Cladonia* and any of the bryophytes which have been cited as characteristic of crevices in the rock outcrop series. It also commonly includes certain more mesophytic species, such as *Ptilidium ciliare*, *Hypnum Schreberi*, and *Hylocomium splendens*. The lichen–bryophyte element may perform an important function in the succession by forming cushions and mats which often spread away from the crannies over the adjoining rock surfaces, creating a substratum favorable for the germination of the spores and seeds of higher plants. The presence in the crannies of a soil, however, permits the growth at the outset, not only of lichens and bryophytes, but of vascular plants as well. Herbaceous plants are sparingly represented by *Polypodium vulgare* and a few other species, while the two shrubs, *Sambucus racemosa* and *Rubus idaeus canadensis*, usually occupy a prominent position. But both herbs and shrubs are subordinate in importance to trees. These gain a foothold early and may predominate the succession from start to finish. For a long time, at least as long as the intermittent bombardment of the slope continues by

rocks dislodged from above, the trees remain scattered, and, at this stage, paper birch commonly is the most conspicuous tree. The reason for this frequently observed predominance of paper birch over conifers at this time, as pointed out by Cooper ('13, pp. 218, 219), is undoubtedly due to the ability of the former to sprout from the stump and thereby recover from the injuries inflicted by falling boulders. Ultimately, a coniferous forest of the type already described may become established, in which the predominant trees include the balsam fir and white spruce, the paper birch and yellow birch, the white pine, the black spruce and mountain ash. On north-facing slopes, coniferous forests, while attaining a high degree of mesophytism, frequently represent the culminating phase of the succession: in other words, they constitute an edaphic climax. But, under favorable conditions, the regional climax association-type is capable of attainment on boulder talus, as on the glacial drift.

The association-types of gravel slides.—In extreme cases, as, for example, on gypsum slides[10] (Fig. 15), the instability of the rock mass may be so great that plant life is almost excluded. Largely on account of this instability, lichens and mosses usually play but little part in gravel slide successions: only plants with roots are capable of maintaining a foothold here. The most important pioneers are xerophytic ferns and seed plants, especially herbaceous forms which perennate by means of roots and rhizomes: such species, for example, as *Pteris aquilina, Dicksonia punctilobula, Danthonia spicata, Campanula rotundi-*

[10] In this connection it is worthy of note that floristically the vegetation of gypsum outcrops commonly differs to a marked degree from that of other rock outcrops which may be physically similar. On the gypsum the vegetation includes a pronounced calciphilous element which elsewhere is mostly absent. Prominent among the seed plants are *Carex eburnea, Shepherdia canadensis, Cornus circinata,* and *Erigeron hyssopifolius.* The bryophytes include *Swartzia inclinata, Gymnostomum rupestre, Tortula mucronifolia, Encalypta contorta, Myurella Careyana,* and *Thuidium abietinum.* Generally speaking, however, while there are frequent other evidences throughout this region of a similar correlation between the chemical nature of the underlying rock and the character of the vegetation, the writer has been unable to distinguish any broad relationships of general ecological significance. Aside from the influence of topography, the general aspect of the vegetation appears to be correlated more with the physical character of the substratum than with its chemical character.

folia, Anaphalis margaritacea, and *Solidago bicolor.* Most of the weeds found in pastures and along roadsides thrive on gravel slides. Of the herbaceous plants, the grasses, particularly *Danthonia spicata,* commonly play an essential rôle, contributing to bring about increased stability in the substratum through the formation of a more or less continuous sod. Shrubs, notably *Rubus idaeus canadensis,* and trees, especially the white spruce, are also important in this respect.

FIGURE 15.—Gypsum ("plaster") outcrop along shore of Ingonish Harbor.

Sometimes a xerophytic weed stage in the succession, in which the plants are scattered and the vegetation open, is followed by a definite grass stage, in which the ground is completely carpeted by vegetation. But more commonly trees are present from the outset, and the first continuous plant cover is dominated by trees, which form an open grove, the ground between the trees being grassed over or else occupied by colonial herbaceous species, such as *Dicksonia* and *Anaphalis,* or by *Rubus.* The white spruce invariably stands preëminent among the trees, but there is a scattered representation of balsam fir, paper birch, balsam poplar,

bird cherry (*Prunus pennsylvanica*), etc. In the course of time a closed coniferous forest may be developed, and, under favorable conditions, this may be superseded eventually by a forest of the regional climax type.

One of the commonest types of talus in northern Cape Breton is shown in Fig. 16. The rock fragments are relatively small and the rock mass is much less stable than the large-bouldered talus, though more so than the gravel slide. The common

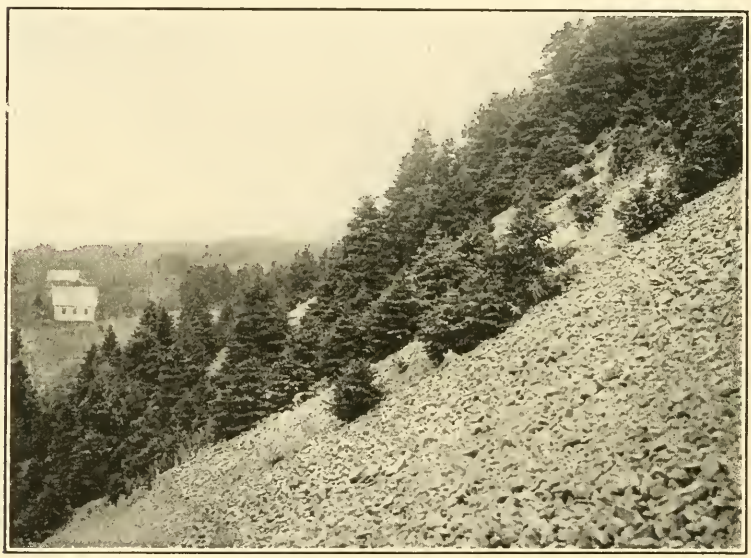


Figure 16.—Pioneer association of white spruce, etc., on granitic talus; Barrasois.

pioneers here are the white spruce, the raspberry, *Dicksonia,* and *Anaphalis.*

2. The Formation-types of Uplands along Streams

a. Introductory

In a general way, two topographic features are intimately associated with streams: valleys and flood plains. In northern Cape Breton the valleys range from deep, narrow ravines and gorges in which the stream occupies entirely the narrow floor, on

the one hand, to wide, open valleys with broad, flat floor, on the other. All of the larger streams, in their passage from the interior toward the coast, flow during at least part of their course through deep valleys (Fig. 17), while on a lesser scale ravines are well developed along many of the small brooks. In general, so far as the larger streams are concerned, narrow ravines (Fig. 19) are more characteristic of the higher, crystalline areas, broad valleys of the lower Carboniferous regions. Broad, open

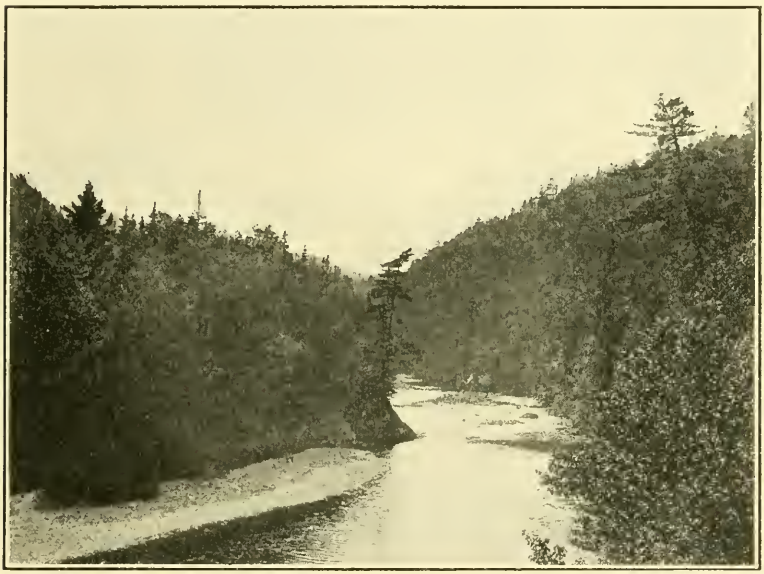


Figure 17.—Valley of Barrasois River, just above contact between crystalline and Carboniferous areas; *Pinus Strobus* in right and left foreground. Compare with Fig. 18, photographed but a short distance downstream.

valleys (Figs. 7, 20) are especially well developed in the zone of contact between the lowland and the highland, where very frequently the Carboniferous lowland extends as a finger-like depression for several miles into the heart of the higher crystalline formation. The floor of such a valley, as a rule, is relatively flat and is referred to locally as an *Intervale*.

The glacial débris, which at one time must have buried the floor of every valley to a considerable depth, has been very largely

scoured out from the narrow-floored ravines through stream activity; but in the broad-floored valleys, as throughout the Carboniferous lowland in general, it may still form, at least locally, deposits many feet thick. Wherever these heterogeneous deposits are exposed to the erosive action of the current, the finer materials tend to be carried away, the coarser constituents being left behind and forming what are here designated as *Boulder Plains*—areas covered with stones, mostly rounded, but

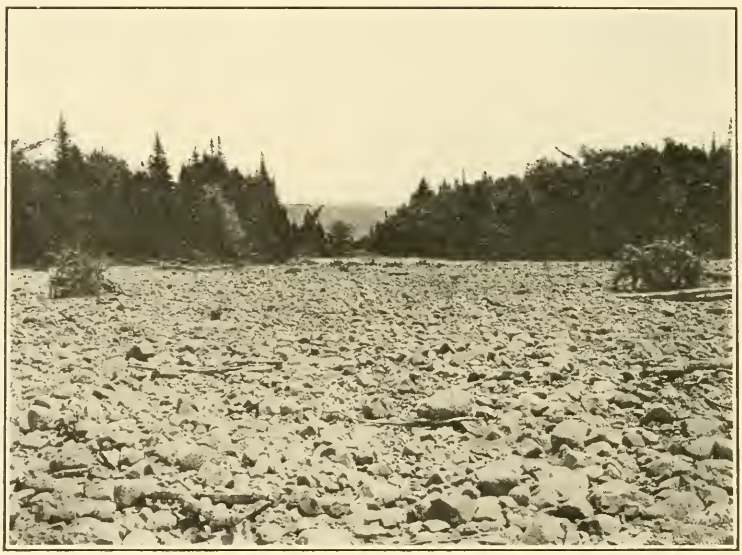


FIGURE 18.—Boulder plain along lower course of Barrasois River.

of all shapes and sizes (FIGS. 18, 21). Where the stones are uniformly small, they may well be referred to as *Cobble Plains*. These stony plains commonly border the larger streams wherever they flow through deposits of glacial drift. In flood time they are submerged, but ordinarily, except for the small channel permanently occupied by the stream, they are uncovered.

In contrast to boulder plains, which are a result of degradation, flood plains are a product of aggradation. They are best developed along sluggish, old-age rivers, and at first thought might not be expected to occur at all along swift, young streams, like the majority of those in northern Cape Breton. But, on

the contrary, even in narrow ravines incipient flood plains may be commonly observed in situations which in some way are protected from the swift current (foreground in FIG. 17), while in wider valleys (FIG. 20) the stream is usually bordered by an interrupted series of low, terrace-like flood plains, which have been built up along the less exposed banks. The flood plains of rapid streams, however, not only in Cape Breton, but elsewhere as well, differ markedly from the familiar type of sluggish streams. There the alluvial deposits consist largely of fine-grained sediments. Flood plains of this latter sort, in northern Cape Breton, have been developed to a considerable extent locally, particularly toward the mouths of some of the larger rivers. Along rapid water courses, however, the deposits are much coarser, the swiftness of the current in times of flood being so great that most of the finer material is washed away. Even where the conditions for deposit are most favorable, the alluvial material along a rapid stream is made up largely of coarse sand and gravel, while miniature flood plains built up almost wholly of cobbles and pebbles are frequent in less favorable situations. Incidentally, it should be remarked that while, in a sense, a boulder plain might be regarded as a flood plain, for obvious reasons it is best treated separately. Typical flood plains commonly overlie former boulder plains.

b. THE ASSOCIATION-COMPLEXES OF ROCK RAVINES

This is the only type of ravine which need be considered. The associations here may be divided roughly into four groups, as follows. (*1*) The stream bed association-types: comprising the vegetation in areas where the bottom is submerged at all seasons. (*2*) The stream bank association-types: comprising the vegetation of areas, mostly along the margin of the stream, which are flooded at times of high water but at other times, of variable duration, are exposed to the air. (*3*) The association-types of cliffs: comprising the vegetation of areas above the flood zone which are too steep or unstable to support a forest. (*4*) The ravine forest. With reference to their water relations, some of these association-types are naturally classed under the xerarch series, others under the hydrarch series, but this classification is not always easy to apply. In the hydrarch category should of

course be classed the stream bed association-types, and here also it seems most appropriate to include those stream bank and cliff association-types whose ecological aspect is obviously correlated with the more or less constant presence of an abundant water supply. Similarly, in the xerarch category should be classed the ravine forest and such of the association-types of stream banks and cliffs as are exposed for considerable periods of time to more or less xerophytic conditions. In the present connection

FIGURE 19.—Gorge along Indian Brook; the upper edge of the flood zone is indicated by the lower margin of the forest.

attention is directed primarily to ravine associations of the xerarch series. Apropos, it may be remarked that, for reasons which the author has pointed out elsewhere ('16[b], pp. 237, 249, 250), in considering the vegetation of rock ravines from the dynamic point of view, the question of an actual succession of plant associations, in so far as it is correlated with the physiographic development of the ravine itself, may be virtually disregarded.

Stream bank association-types.—Largely owing to the narrowness of the channel to which the rushing flood water ordinarily is

confined, the character of the vegetation within the flood zone in ravines is influenced to a marked degree by the abrading action of the current at times of high water. Particularly is this true along the larger streams (FIGS. 17, 19), to which the following remarks primarily apply. Woody plants, for the most part, are either absent or sparsely developed and even the herbaceous plants are scattered. The characteristic vascular plants of rocky banks between high and low water levels are herbaceous perennials, and these are mostly restricted to crevices and similar situations where their perennating roots and rhizomes can maintain a foothold. Common species are *Equisetum sylvaticum, Deschampsia flexuosa, Sagina procumbens, Campanula rotundifolia, Erigeron hyssopifolius,* and *Solidago bicolor,* together with various weeds, such as *Prunella vulgaris, Achillea Millefolium,* and *Chrysanthemum Leucanthemum.* In addition to these, a prominent position is frequently occupied by various bryophytes, such species as *Preissia quadrata, Fossombronia foveolata, Marsupella emarginata, Nardia obovata, Hygrobiella laxifolia, Grimmia apocarpa, G. conferta,* and *Racomitrium aciculare.* Toward the upper margin of the flood zone, skirting the lower edge of the ravine forest, there is commonly a narrow fringe of shrubs which constitutes a more or less distinct association-type. The characteristic species here is *Alnus mollis,* with which may be associated *Salix humilis, Rubus pubescens, Acer spicatum, Diervilla Lonicera,* and other shrubs, together with such herbaceous mesophytes as *Osmunda Claytoniana, Phegopteris polypodioides, Streptopus amplexifolius,* and *Solidago latifolia.*

Conditions similar to those just outlined may prevail in ravines along small streams, but here the stream bank vegetation commonly is such that it has seemed best to treat it under the hydrarch series (see p. 368).

Cliff association-types.—Certain pteridophytes are especially characteristic of crevices in cliffs, well above the level of the stream, notably *Polypodium vulgare, Aspidium fragrans, Cystopteris fragilis, Woodsia ilvensis,* and *Lycopodium Selago.* With the exception of perhaps the last-named species, these grow best in moist, somewhat shaded habitats. Various of the herbaceous perennials of the flood zone are equally common here, particularly *Deschampsia* and *Campanula,* while the crevice plants mentioned earlier in connection with the rock outcrop series of ordinary

uplands may likewise be well represented. Of special interest, however, is the conspicuous position commonly occupied by the mosses and liverworts, which, in favorable situations, may develop luxuriantly, growing either in crevices or on sloping or perpendicular rock surfaces. Representative species are listed below, and, in addition to these, various of the species of wet cliffs (p. 370) may grow here.

Bazzania tricrenata
Diplophyllum taxifolium
Porella platyphylloidea
Radula complanata
Lejeunea cavifolia
Andreaea petrophila
Swartzia montana
Fissidens osmundoides
Tortella tortuosa
Racomitrium fasciculare
Ulota americana
Pohlia cruda
Bartramia pomiformis
Hedwigia albicans
Drepanocladus aduncus
Polytrichum alpinum

The ravine forest.—Nowhere in the lowland of northern Cape Breton are forests of the coniferous type more luxuriantly developed than in ravines. In general, these forests conform closely with the regional climax type of the mountains, and need not be described in detail at this point. Such forests here represent an edaphic climax association-type, and as such their development is correlated very largely with local peculiarities of temperature and soil moisture. They are best developed on north-facing slopes, where the failure of the succession to proceed beyond the coniferous forest stage may be attributed to the slowness with which the snow melts and the ground thaws out in spring and to the relatively low temperatures which obtain throughout the season. Quite commonly the north-facing slope of a ravine supports a coniferous forest while the opposite, south-facing slope is clad with a forest of the regional climax type. On north-facing slopes, coniferous climax forests are by no means confined to ravines: one of the most distinctly boreal examples of upland forest which has come to the writer's attention in the lowland is situated along the lower slopes of a steep mountain side, where ice frequently lingers as late as August, notwithstanding the fact that it faces an open intervale which was formerly occupied by a deciduous forest. In ravines which

run north-and-south, and where both flanks are thus equally well exposed to the sun, on the other hand, the ravine forest may be wholly of the deciduous type.

One feature of coniferous ravine forests worthy of special mention is their great mesophytism, as evinced more particularly by the wonderful development of the bryophytic ground cover. Commonly the ground beneath the trees is literally buried beneath a thick bed of liverworts and mosses. The sphagnums in particular—such species as *Sphagnum capillaceum tenellum, S. Girgensohnii, S. quinquefarium,* and *S. subsecundum*—commonly form wide, deep cushions, flourishing here as in no other upland habitat in this region.

The summer evaporating power of the air in coniferous ravine forests, as compared with other habitats.—During the summer of 1915 a series of porous cup atmometers was operated, for a period of a little more than two weeks, in various habitats, with the object, primarily, of ascertaining the relative evaporating power of the air in coniferous ravine forests as compared with the deciduous climax forests. The habitats selected were as follows:

Station 1 ("Open—Shore"): Open hillside, east exposure, half a mile from seacoast.

Station 2 ("Open—Intervale"): Open hillside, east exposure, four miles from coast at head of intervale.

Stations 3 and *4* ("Hardwood"): Hardwood (climax) virgin forest; east exposure; near station *2*.

Station 5 ("Ravine Conifer—High"): Coniferous forest; steep north-facing slope of ravine, about 250 feet above river; near station *1*.

Station 6 ("Ravine Conifer—Low"): Dense coniferous forest; steep north-facing slope of ravine, about 150 feet above river; near station *1*.

Station 7 ("Ravine—Bed"): Gravel bar in bed of stream; exposed to sun about six hours daily; stream bed about 75 feet wide at this point; near station *1*.

The readings obtained are given in Table VI. During much of the period that the cups were in operation the weather was intermittently rainy, foggy, and clear. From August 3 to August 7, however, it was uninterruptedly clear, so that for pur-

TABLE VI

RATE OF EVAPORATION IN VARIOUS HABITATS, AS INDICATED BY THE POROUS CUP ATMOMETER

	July 22–July 27	July 27–August 3	August 3–August 7	Total
Station 1: Open—shore	28.8 cc.	45.0 cc.	84.2 cc.	158.0 cc.
Station 2: Open—intervale	39.4 cc.	53.3 cc.	91.9 cc.	184.6 cc.
Station 3: Hardwood A	16.0 cc.	19.6 cc.	42.1 cc.	77.7 cc.
Station 4: Hardwood B	15.3 cc.	16.3 cc.	37.8 cc.	69.4 cc.
Station 5: Ravine Conifer—high	14.4 cc.	20.6 cc.	52.5 cc.	87.5 cc.
Station 6: Ravine Conifer—low	11.0 cc.	14.0 cc.	43.3 cc.	68.3 cc.
Station 7: Ravine—bed	24.1 cc.	31.1 cc.	63.0 cc.	118.2 cc.

pose of comparison the third column of figures is the most reliable. From an examination of these figures various facts are obvious, but only one of these need be emphasized, namely, that the evaporating power of the air in the coniferous ravine forest differs little from that in the climax deciduous forest. Greater humidity, then, will not explain the luxuriant development of the moss carpet in a ravine forest. Other explanations have already been suggested.

c. THE ASSOCIATION-COMPLEXES OF OPEN VALLEYS

Chiefly by reason of the protection which they afford from cold winds in spring and fall, open valleys (FIG. 20), in general, present edaphic conditions which are more congenial to plants of southward distribution than those of any other type of habitat-complex. Robinson ('03) has already called attention to the relative abundance in the intervales of eastern Nova Scotia of early spring-flowering plants, and the writer (16[b], pp. 252, 253) has commented on parallel conditions in Connecticut. Nowhere in northern Cape Breton are forests of the deciduous-hemlock climax type more luxuriantly developed than on the floors of broad, sunny valleys, i. e., in the intervales. Here, more abundantly than anywhere else, grow the hemlock, red oak, white ash, and elm (*Ulmus americana*), among the trees, together with various herbaceous plants of pronounced southward range. Of the latter, many forms, such as *Anemone virginiana, Sanguinaria canadensis,* and *Dicentra Cucullaria* (*fide* Robinson '03), *Actaea alba, Epifagus virginiana,* and *Triosteum aurantiacum,*

are practically restricted to the intervales or to the adjoining slopes. From the standpoint of their physiographic origin, the intervales are largely the result of stream activity, and their vegetation in part is that of the boulder plains and flood plains which are still in the course of formation. But in large part, so far as the vegetation is concerned, the influence of the stream is of merely historical significance. In the case of boulder plains and flood plains, local soil as well as local atmospheric factors have to be taken into account.

FIGURE 20.—The Big Intervale along North Aspy River: floor of valley at this point largely under cultivation; in background, talus slopes in various stages of forestation; view taken toward upper end of intervale; compare FIG. 7.

d. THE ASSOCIATION-COMPLEXES OF BOULDER PLAINS

In extreme cases, vegetation may be almost wholly lacking on boulder plains (FIG. 18). But such cases are not common. While from a distance the lower and more frequently flooded portions of a boulder plain may have almost the aspect of a desert, closer inspection usually reveals, even here, a goodly representation of shrubs and herbaceous plants, which maintain a precarious foot-

hold in the interstices between the cobbles and boulders, rooting in the sand and gravel which have accumulated in the shelter afforded by the larger rocks. The pioneers are preëminently herbaceous perennials: species which are able to tide over the unfavorable periods by means of underground organs. Except for shrubby willows (such species as *Salix cordata, S. lucida,* and *S. humilis*), which are able to survive considerable battering and

FIGURE 21.—View along Middle River, showing boulder plain with scrubby willows, etc. (left foreground), young flood plain with pioneer tree stage (center, mid-distance), and mature flood plain, now under cultivation (right, mid-distance).

locally may form dense, low thickets (FIG. 21), woody plants are scarce.

On the higher parts of a boulder plain, the vegetation is much more abundant, but always open. In addition to the willows, species of alder, particularly *Alnus incana,* are ordinarily conspicuous here, together with such other woody plants as *Rubus idaeus canadensis, R. pubescens,* and *Spiraea latifolia.* A list of some of the more characteristic herbaceous plants of boulder plains is given below. This list does not include weeds, many of which occupy a very prominent position here.

Equisetum arvense
Calamagrostis canadensis
Agropyron repens
Poa pratensis
Carex torta
Ranunculus repens
Fragaria virginiana
Viola cucullata
Viola pallens
Epilobium angustifolium
Epilobium adenocaulon
Apocynum cannabinum
Eupatorium purpureum
Solidago canadensis
Aster radula
Aster puniceus

e. THE ASSOCIATION-COMPLEXES OF FLOOD PLAINS

Transition from boulder plain to flood plain.—It commonly happens, sooner or later, that the stream shifts its course or that the current is deflected by some sort of an obstruction, so that an area occupied by a boulder plain becomes protected in a measure from the erosive activity of the stream. If the protection is sufficient, degradation may become largely superseded by aggradation, and a flood plain may gradually be built up on top of the former boulder plain (FIG. 21). Eventually, even along swift stretches of the stream, such flood plains may attain a height of five or six feet above low water level. At first composed of coarse gravel and cobbles, as the surface is raised higher the successive deposits become finer, and finally the soil comes to consist of coarse sand. Only in exceptionally favorable situations, however, does the soil approximate the fine alluvium of old-age rivers.

The succession of plant associations outlined.—In the familiar type of flood-plain succession (to be discussed later), the pioneer stages of the series are usually hydrophytic: in other words, the succession is hydrarch. In the boulder plain–flood plain succession, on the other hand, the pioneer stages, as a rule, are relatively xerophytic: that is, the succession is xerarch. Three more or less distinct stages in the succession may be distinguished: the gravel bar stage, the pioneer tree stage, and the edaphic climax forest.

The gravel bar association-type.—The pioneer association-type of gravel bars consists largely of the shrubs and herbaceous perennials listed as characteristic of boulder plains, most of which grow in greater profusion here than there. It also may include many species which are not prominent on boulder plains: such, for example, as *Alnus mollis* and *Diervilla Lonicera; Campanula*

rotundifolia, Anaphalis margaritacea, and *Centaurea nigra.* The mosses, *Racomitrium canescens* and *Polytrichum piliferum,* frequently form a loose, discontinuous ground cover in protected spots; while species of *Cladonia* may also be present. Locally, wherever the soil is fairly moist, the early vegetation may include mesophytic species, such as *Clematis virginiana, Thalictrum polygamum,* and *Heracleum lanatum*—forerunners of subsequent stages in the succession.

The pioneer tree association-type.—Although the vegetation in the gravel bar stage of the succession is predominated by shrubby and herbaceous species, trees may be present from the outset. The balsam poplar, more than any other species, is preëminently the distinctive pioneer tree of gravelly or sandy flood plains, although it often shares this honor with the paper birch and white spruce (Fig. 21). The balsam poplar owes its prominence to its copious root system and exceptional ability to maintain itself on shifting alluvial soils, its tendency to reproduce and spread by means of root suckers, and its rapid rate of growth, which enables it to outstrip any chance competitors. In these respects it resembles its southern relative, the cottonwood (*Populus deltoides*), of which it may be regarded as an ecological counterpart. One frequently encounters on flood plains groves of good-sized balsam poplars, beneath which the more characteristic trees of the climax forest apparently are just beginning to establish themselves. But any of the climax trees may appear simultaneously with the poplar. On one small, treeless stretch of gravelly flood plain, for example, the writer noted seedlings of nearly every tree (all except white pine, hemlock, and red oak), which has been cited earlier as growing in the climax forest; also seedlings of bird cherry and choke cherry (*Prunus virginiana*). For the reasons suggested above, however, the poplar usually gains a temporary ascendancy over its competitors, thereby giving rise to a more or less distinct phase in the succession.

The edaphic climax forest.—Flood plain forests of the sort ordinarily associated with old-age rivers have been developed along some of the larger lowland streams, and in some cases the physiographic history of the areas which these occupy has probably been similar to that of flood plains as described in the preceding paragraphs. But in the most typical instances

observed, such forests represent the culmination of hydrarch rather than xerarch successional series, and they will therefore be discussed later (p. 371), in connection with hydrarch successions.

The average climax forest of sandy flood plains along swift streams approximates closely the climatic climax forest-type of the region, differing from this chiefly in the presence, or more luxuriant development, of such species as *Ulmus americana* and *Fraxinus americana*, among the trees, and of various herbaceous plants, such as the following:

Osmunda Claytoniana	*Streptopus amplexifolius*
Polystichum Braunii	*Thalictrum polygamum*
Cinna latifolia	*Sanicula marilandica*
Trillium cernuum	*Osmorhiza divaricata*
Smilacina racemosa	*Pyrola asarifolia*
Listera convallarioides	*Solidago latifolia*

3. The Formation-types of Uplands along the Seacoast

a. INTRODUCTORY

Under this heading are included only those upland associations which are peculiar to habitats in the immediate proximity of the shore and whose ecological aspect is obviously correlated with this fact. The character of vegetation along the seacoast is influenced to a greater or less degree by wind, salt water, and physiographic agencies. The plant associations are best classified with reference to physiographic factors, as (*1*) Associations along Eroding Shores, and (*2*) Associations along Depositing Shores. As eroding shores are classed the sea bluffs and headlands which form such a striking topographic feature along much of the coastline. Depositing shores include the commonly encountered shingle beaches and the less frequently encountered sandy beaches and dunes.

In addition to the figures that accompany the description which follows, attention may be called in this connection to FIGS. 3, 6, 8, 15, 33, 38, 41.

b. THE ASSOCIATION-COMPLEXES OF SEA BLUFFS AND HEADLANDS

Association-types of rocky sea bluffs.—The application of the term sea bluff is here restricted to the more or less precipitous

slopes which face directly on the shore and therefore are most exposed to the action of waves and spray (Fig. 3). Along such bluffs there is usually a pronounced zonational arrangement of plant associations. Between low and high tide levels, wherever the base of the bluffs is submerged, the rocks are usually plastered with sea-weeds, prominent among which are species of *Fucus* and *Ascophyllum*. Above high tide level is a zone of varying width in which, owing largely to the mechanical action of waves

Figure 22.—*Juniperus horizontalis* on sea bluff; Middle Head, Ingonish.

and ice, vegetation is absent. Higher up, and sometimes reaching to a height of thirty-five or forty feet, is a zone in which the vegetation consists largely of scattered halophytic crevice plants. The upper limits of this zone are presumably determined by the height of the waves in winter storms. The most abundant plant here is *Plantago decipiens*, along with which commonly grow *Solidago sempervirens* and *Sagina procumbens*—the latter, of course, hardly to be considered a typical halophyte. Other halophytic species which may inhabit crevices or ledges toward the upper edge of this zone and which, like the preceding, may also occur on low headlands far beyond the actual reach of the waves, are *Potentilla pacifica*, *Atriplex patula hastata*, and *Lathyrus maritimus*. The most characteristic plant on that part

of a bluff which lies beyond the usual reach of the waves is the trailing juniper (*Juniperus horizontalis*), which commonly sprawls out here in great profusion (Fig. 22), and is only occasionally found in any other habitat. Commonly associated with this shrub is the crowberry (*Empetrum nigrum*) and frequently the low juniper (*Juniperus communis depressa*), while any of the other species to be cited presently as occurring on headlands may also grow in the crevices of precipitous, rocky sea bluffs.

Figure 23.—*Alnus mollis* and *Picea canadensis* on sea bluff of clayey drift; Cape North.

Association-types of sea bluffs in uncompacted rock.—So long as a sea bluff of clay or glacial drift continues to be acted on, from time to time, by the waves, vegetation is scantily developed. Just as along the shores of the Great Lakes (see Cowles '01, pp. 164–167), about the only plants present here are xerophytic annuals and "slump plants" (i. e., plants which have slid down from the crest of the bluff). As soon, however, as there is a cessation or diminution in the erosive activity of the waves, which may be brought about by the formation of a shingle beach between the bluff and the sea or through the accumulation along the base of the bluff of boulders derived by erosion from the

bluff itself, a plant cover is rapidly developed. *Equisetum arvense* and *Agrostis alba maritima* frequently, and *Elymus arenarius* occasionally are conspicuous pioneers, but for the most part the pioneer species here are largely weeds and slump plants. Sometimes a grassy sod is formed, but more commonly *Alnus mollis* (Fig. 23) comes in along with the grasses and forms a dense thicket. Sooner or later, trees appear, mostly white spruce and paper birch, and these may supersede the alders, forming a low, scrubby forest along the bluff. The trees often exhibit the same one-sided habit as those on headlands.

Figure 24.—Exposed rocky headland at White Point; scrubby forests, mostly white spruce; in right foreground a characteristically one-sided spruce. Photograph by Dr. L. H. Harvey.

Owing to the abundance of seepage water, soil conditions locally, especially along clay bluffs, may be unusually favorable for plants, and in such places it is a common thing to find the vegetation made up in large part of species which are ordinarily associated with swamps or flood plains: such, for example, as *Alnus incana, Calamagrostis canadensis, Juncus effusus* and various sedges, *Heracleum lanatum, Eupatorum purpureum,* and *Aster puniceus.* Associations of this sort, though mentioned here for convenience, should naturally be classed under the hydrarch series.

Association-types of exposed headlands.—Bleak headlands like the one pictured in Fig. 24 are a prominent feature of the coast,

especially northward. In the vicinity of Cape North and in other very exposed situations the mountain sides in some places are devoid of forest from sea level to a height of fully a thousand feet. Without doubt many of these areas were formerly wooded and their barren aspect has been induced primarily through the action of fire or human activity; but the continuance of this condition is attributable very largely to the retarding effect on succession of exposure to strong winds, frequently laden with

FIGURE 25.—Detail view of vegetation on exposed headland shown in FIG. 24; see text. Photograph by Dr. L. H. Harvey.

salt spray. Wherever, on headlands of the sort pictured, there is a depression which affords shelter, scrubby forests are encountered, while scattered trees are commonly present in the barren area itself. These latter, as well as many of the trees which fringe the lower margin of the forest farther up the slope, are usually unsymmetrical in shape and dwarfed in size. Frequently the living part of the crown is wholly on the landward side of the tree.

In some cases the predominant type of vegetation on these headlands is grass: species such as *Danthonia spicata*, *Festuca rubra*, and *Deschampsia flexuosa*. But more often (FIG. 25)

the ground is covered very largely with a dense tangle of low, sprawling shrubs which are seldom more than a foot high. Perhaps the most characteristic, and commonly the predominant shrub is the crowberry, but associated with this and often equally abundant may be *Juniperus communis depressa, Vaccinium Vitis-Idaea, V. pennsylvanicum,* and occasionally *Juniperus horizontalis.* Other species commonly encountered on bleak, exposed headlands, but not yet mentioned in this connection, are listed below.

Botrychium ramosum
Smilacina stellata
Iris setosa canadensis
Myrica carolinensis
Arenaria lateriflora
Fragaria virginiana
Potentilla tridentata
Lathyrus palustris
Ligusticum scothicum
Cornus canadensis
Gaultheria procumbens
Halenia deflexa
Euphrasia Randii
Euphrasia Randii Farlowii
Campanula rotundifolia
Solidago puberula
Aster novi-belgii

To these should be added *Cladonia* sp., *Polytrichum piliferum,* and *Polytrichum juniperinum,* which frequently carpet the bare soil where other vegetation is absent.

c. THE ASSOCIATION-COMPLEXES OF BEACHES AND DUNES

Association-types of shingle beaches.—Even along parts of the coast which are exposed to active erosion, at least where the eroding land mass consists of glacial drift, a rocky, beach-like strip commonly intervenes between the foot of the bluff and the water's edge. Such deposits may be composed in part of wave-washed material, but as a rule they are largely made up of boulders and cobbles of all sizes which have been washed out of the bluff itself. The analogy with the boulder plain is obvious. All degrees of transition exist between such deposits, which may be virtually destitute of vegetation, and the typical shingle beaches, which constitute a familiar feature along the shore. These latter commonly form a narrow fringe along the seaward edge of the land, but wherever there are reëntrants in the coast line, barriers and spits tend to be developed. St. Ann's Bay and Ingonish Harbor are nearly closed in by narrow, rocky spits,

and there are similar spits at the mouth of the Barrasois River and Indian Brook. Near the Barrasois and at South Bay, Ingonish (Fig. 42), lakes of considerable size have been cut off from the sea by barriers, the one at the latter place being fresh and several feet higher than high tide level. Small ponds and lagoons, cut off by barriers, are of frequent occurrence (Fig. 26).

In a general way, a shingle beach, like a sandy beach, is subdivided into three more or less distinct zones which, following the classification of Cowles ('01, p. 170), may be termed respectively the lower, middle, and upper beaches (Fig. 27). The lower

Figure 26.—Shingle beach enclosing small fresh pond; scrubby spruces, etc. in foreground, habit largely the result of grazing; in background, second growth spruce, etc.; Wreck Cove. Photograph by Dr. L. H. Harvey.

beach is the part submerged by ordinary high tides. It ranges in width from a few yards to more than a hundred feet. The deposit here (at least in summer) is usually gravelly or sandy toward its lower limit, becoming pebbly above and gradually merging with the shingle. Except for the occasional presence near low tide level of *Zostera marina* and brown algae such as *Fucus,* vegetation is absent. The middle beach comprises that part of the beach immediately above the lower beach which is swept by the waves of winter storms or is covered over by ice in winter. Like the lower beach, it varies greatly in width. The deposit here consists almost wholly of water-rounded cobbles

and pebbles, ranging from the size of hens' eggs up to six inches or more in diameter—the type of accumulation commonly referred to as *Shingle*. Vegetation is sparse and xerophytic, practically the only plants ordinarily present being the annual, *Cakile edentula,* and the herbaceous perennials, *Lathyrus maritimus* and *Mertensia maritima*. The last-named species, the so-called sea lungwort, with its glaucous foliage and rose-pink or blue flowers, and growing in depressed, circular patches two or

FIGURE 27.—Shingle beach near mouth of Barrasois River; forest of white spruce, etc. along landward edge.

three feet in diameter, is by far the most striking of the beach plants. The upper beach includes that part of the beach which, except during unusual storms, when parts or all of it may be wave swept, lies beyond the reach of the waves at all seasons of the year. Its crest is commonly more than three and occasionally as much as six or eight feet higher than ordinary high tide level. Stones are cast up on these higher beaches only by exceptionally severe storms, perhaps years apart. Like the middle beach, the upper beach, especially in its more exposed parts, may be little more than a great stone heap on which, except for a frequently

luxuriant growth of lithophytic lichens, vegetation is scantily developed. Common lichens on the shingle are *Rhizocarpon geographicum* (crustose), a form which is very conspicuous by reason of its bright, greenish yellow color, and *Lecidea tenebrosa* Flot. (crustose) and *Gyrophora hyperborea* (foliose), both of which are blackish in color. As a rule, however, even in such places, there is more or less gravel and coarse sand underneath the stony surface layer, while in the older parts of the upper beach the shingle in some cases (Fig. 28) has been covered over

Figure 28.—Spit near mouth of Barrasois River; to right, a typical shingle beach; to left, a mixture of sand and shingle, overgrown with *Ammophila*, white spruce, etc.

by sand to such an extent as to produce conditions approximating those to be described presently as characteristic of sandy beaches. All intergradations may be found on lea slopes between rocky shingle at one extreme and sandy beach at the other.

On the upper beach, soil conditions usually favor the development of vegetation, and there may be a succession of plant associations leading to the formation of a scrubby forest. The pioneer plants here are predominantly herbaceous, and various introduced weeds figure prominently. Indeed, almost no other natural habitat supports a greater variety of weeds than shingle beaches. In this connection it may perhaps be remarked that

there seems little question that in former days, in so far as they were then represented in this region, the majority of the plants popularly classed as weeds, and which to-day thrive in a variety of open situations created by man's activity, were restricted to situations such as gravel slides; boulder plains, sandy flood plains and rocky banks along streams; and sea beaches. Excluded through competition from situations edaphically more favorable to them, the weeds, which as a group are essentially pioneers, have always flourished in these open situations.

In addition to the weeds, the grasses are well represented on the upper beach by such species as *Ammophila arenaria, Danthonia spicata, Poa compressa, Poa pratensis, Festuca rubra,* and occasionally *Elymus arenarius,* while the sedge, *Carex silicea,* is seldom absent. Other common herbaceous species here are *Fragaria virginiana, Potentilla tridentata, Geranium Robertianum, Oenothera muricata, Ligusticum scothicum, Campanula rotundifolia,* and *Anaphalis margaritacea.* Various xerophytic mosses, notably *Ceratodon purpureus, Racomitrium canescens, Brachythecium albicans, Polytrichum juniperinum,* and *Polytrichum piliferum,* thrive in open, gravelly soils, while the foliose lichens, *Cladonia rangiferina, C. sylvatica,* and *Stereocaulon coralloides* may also be represented. But the vascular vegetation is by no means restricted to herbaceous forms, for even on rocky and quite exposed parts of the beach there usually are scattered shrubs and trees. In stony situations the plants may secure a foothold in patches of gravel between the cobbles, but very frequently a favorable substratum is created by the decomposition of logs which have been cast up by storms. Of the shrubs, *Juniperus communis depressa, Myrica carolinensis, Rubus idaeus canadensis, Empetrum nigrum, Gaylussacia baccata,* and *Vaccinium pennsylvanicum* are quite characteristic of shingle beaches, and *Vaccinium Vitis-Idaea* grows well in grassy, gravelly or sandy areas. The commonest tree is the white spruce, though the balsam fir is scarcely less frequent. Both of these trees often exhibit a weather-beaten aspect, but this is especially true of the balsam fir. On the beach at Englishtown (Fig. 29) grow specimens of the latter which measure less than two feet in height but sprawl out on the ground over a radius of more than six feet. Their low stature is due to the repeated killing off of the leader, and this in turn is probably

attributable to the erosive effect of wind-driven snow in winter, a phenomenon which will be referred to again in connection with the vegetation of the barrens.

Wherever a shingle beach borders on the mainland, there is a tendency for the forests of the adjoining upland to encroach on the beach (Fig. 27), and even on barriers and spits scrubby forests are frequently developed on the older parts of the upper beach (Fig. 29), usually on lea slopes where there is optimum

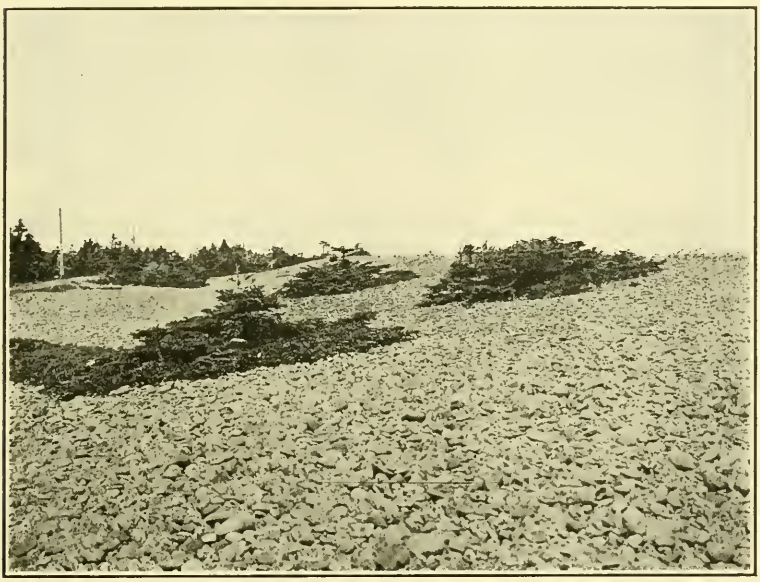


Figure 29.—Stunted balsam firs (foreground) and scrubby forest (left background) on shingle beach; St. Ann's Bay; compare Fig. 33.

protection from wind and wave. Such forests are quite open, and are composed almost wholly of white spruce and balsam fir, which seldom reach here a height of more than twenty-five feet. In the open spaces between the trees grow in more or less profusion various of the shrubs and herbaceous plants which have been listed as occurring on the upper beach, while certain less xerophytic species, which have been cited earlier as characteristic of the pioneer forest stage in the ordinary upland series, are found here also. Common bryophytes in the shade of the trees are *Ptilidium ciliare, Dicranum Bonjeanii, Dicranum undulatum,*

and *Hypnum Schreberi*. On the whole, the aspect of such a forest is quite xerophytic.

Association-types of sandy beaches and dunes.—Aside from their frequent association with shingle beaches, to which reference has been made above, broad strips of sandy beach fringe the mainland here and there in somewhat protected situations along the coast, as at North Bay and South Bay, Ingonish. Frequently such beaches overlie deposits of shingle and during

FIGURE 30.—Sand spit at North Pond, Aspy Bay; *Ammophila*, etc.; in the distance, Cape North.

heavy storms the sand may be completely swept away from the more exposed parts of the beach. The finest display of sandy beach along the coast of northern Cape Breton is seen at Aspy Bay, where North Pond is nearly cut off from the ocean by a sand spit (FIG. 30), which is fully three miles long and averages perhaps a hundred yards in width. South Pond similarly is almost shut in by a shorter but much broader spit, on which have been built up a fine series of sand dunes.

As in the case of shingle beaches, the lower beach here is practically plantless, while the middle beach is populated by a

scattered growth of annual and perennial herbaceous plants which maintain a precarious foothold on the shifting sand. The number of species in this latter zone is small, the only forms noted here being *Ammophila arenaria, Salsola Kali, Arenaria peploides, Cakile edentula, Lathyrus maritimus, Euphorbia polygonifolia,* and *Mertensia maritima.* The lower and middle beaches vary in width. On the South Pond spit, each is about 150 feet wide; but ordinarily they are much narrower. The

FIGURE 31.—Sand dunes with forest of white spruce, etc.; South Pond, Aspy Bay.

upper beach likewise varies in width; at South Pond it is fully 250 feet wide, but this is exceptional. At both North and South Ponds the crest of the beach proper is perhaps four feet above high water mark. At North Pond the upper beach is covered by a broad, low dune which in places rises to a height of eight or ten feet above high water mark. The plant cover here consists mainly of a rank, open growth of *Ammophila,* with which are associated *Lathyrus maritimus* and, locally, *Elymus arenarius.* Over limited areas on the lea slope, the shrubs, *Myrica carolinensis* and *Rosa virginiana,* have replaced the *Ammophila* association. In one place a scrubby forest has been

buried by the sand, but at the present time trees are scarce and of merely sporadic occurrence.

The South Bay spit with its dunes (Fig. 31), from the standpoint of physiographic ecology, affords in itself a study of exceptional interest, and has already been written up in some detail by Dr. Harvey ('18). In crossing the spit from the seaward margin on the east to the "pond," which is between one and two miles wide, one encounters in order (*1*) the lower beach, (*2*) the middle beach, (*3*) the upper beach, and (*4*) the salt meadows and marshes which border the spit on its western side. Along the seaward edge of the broad upper beach is a row, sometimes double but mainly single, of sand-dunes, mostly less than six feet in height, but in one locality rising to fully fifteen feet. Some at least of the dunes have originated in moist depressions, or "pans," in which grow *Juncus balticus littoralis* and *Iris versicolor*. On many of the lower dunes, as might be expected, the sand-reed (*Ammophila*) is the predominant plant, fulfilling in connection with dune-formation the twofold function of (*1*) breaking the force of the wind and causing it to drop part of its burden of sand, and (*2*) binding together and holding, by means of its copious, slender roots, the sand which thus accumulates. More often than not, however (Fig. 32), the sand-reed is absent and in its place occurs a luxuriant growth of wire-grass (*Poa compressa*), which seems fully competent to carry out the functions elsewhere performed by the sand-reed.

Figure 32.—Low dunes at South Pond, Aspy Bay; in foreground, *Poa compressa* acting as a sand-binder.

On the lea slopes of these low dunes, trees germinate, predominantly white spruce, but some balsam fir. The reciprocal relation between these trees and the dunes is rather striking. Germinating in the first place in the shelter of the low dunes, as the trees increase in size they afford an effective wind-break, which in turn is largely responsible for the further increase in the height of the dunes. The bases of the trees may be covered to a depth of six feet or more by sand, but both the spruce and the balsam are able to accommodate themselves to the changed conditions through the development of adventitious roots from the buried part of the trunk. The highest dunes are covered at the crest with good-sized trees which have thus been partially buried.

The dunes very likely would attain a greater height here, were it not for the fact that they are exposed to winds from two directions; the westerly winds which sweep across the pond tend to check the growth of the dunes, which is due mainly to the easterly winds from off the ocean.

In the lea of the dunes, between them and the salt meadows, is a broad stretch of low, sandy "back beach," the surface of which is rolling, and is covered partly by an open coniferous forest, partly by grassy areas with scattered trees. Below is given a list of the vascular plants, exclusive of certain weeds, which occur more or less abundantly in these open tracts.

Juniperus communis depressa	*Fragaria virginiana*
Panicum implicatum	*Potentilla tridentata*
Agrostis alba maritima	*Lechea intermedia juniperina*
Danthonia spicata	*Vaccinium Vitis-Idaea*
Festuca rubra	*Campanula rotundifolia*
Arenaria lateriflora	*Leontodon autumnalis*

The grassy sward is nowhere very close, but the sand is nearly everywhere hidden by the two mosses, *Tortula ruralis* and *Dicranum spurium,* and species of *Cladonia.* In among the trees occur a number of species which were not noted in the more open situations, or only rarely so, such as *Maianthemum canadense, Trientalis americana, Rhus Toxicodendron, Ribes lacustre,* and the mosses, *Dicranum undulatum* and *Hypnum Schreberi.* The branches of some of the white spruces support the most luxuriant growth of the dwarf mistletoe (*Arceuthobium pusillum*) that the writer has ever seen.

B. Secondary Formations of the Xerarch Series

Formation-types Resulting Primarily from Human Activity

a. Association-complexes due to cultivation

Notwithstanding the comparative recency with which this country was settled, deserted farms are a familiar sight, and abandoned farmlands in all stages of revegetation are encountered. It is only through constant grazing and cutting, or repeated mowing, that pastures and meadows can be kept

Figure 33.—Cultivated fields, abandoned pastures, and coniferous second growth forests along St. Ann's Bay; in the left background, the shingle beach which nearly encloses St. Ann's Harbor (compare Fig. 29).

open, for the rapidity with which a neglected field reverts to woodland is even greater here than in southern New England. The association-types which arise in the course of secondary successions subsequent upon cultivation may be considered under two heads: (*1*) the association-types of fallow fields, and (*2*) the association-types of abandoned pastures.

The following figures, in addition to those introduced herewith, illustrate secondary formations: Figs. 3, 9, 15, 24, 41, 42, 46.

The association-types of fallow fields.—For several years after a plowed field has been abandoned its vegetation may consist largely of weeds. Common species in such a habitat are:

Rumex Acetosella	*Solidago graminifolia*
Spergula arvensis	*Achillea Millefolium*
Raphanus Raphanistrum	*Chrysanthemum Leucanthemum*
Prunella vulgaris	*Leontodon autumnalis*
Galeopsis Tetrahit	*Taraxacum officinale*
Plantago major	*Cirsium arvense*

In the early stages of reclamation, so long as the plants are scattered and the vegetation relatively open, both annual and perennial species may be about equally well represented. But as the ground comes to be more densely populated, most of the annuals are crowded out and the plant cover comes to consist almost entirely of species which are perennial. Various grasses, especially *Danthonia spicata* and *Poa pratensis,* appear rather early in the succession, and as time goes on these come to comprise a more and more important element. Sooner or later a continuous mat of vegetation is developed, in which the grasses are usually the predominant plants, and the formerly bare soil becomes covered over by a thin turf. Species of *Cladonia* and *Polytrichum* also commonly play an important part in the development of the turf. With the formation of a grassy sward, the conditions come to approximate those of pastures. A few shrubs and trees may have appeared, but on the whole the succession beyond this point is essentially the same as that in abandoned fields, which is discussed in the following paragraphs.

The association-types of abandoned fields.—The predominant plants in open fields are the grasses. In dry pastures *Danthonia spicata* and *Poa pratensis* are ordinarily the most abundant species, but growing along with these and contributing to the formation of the thin sward may be various perennial weeds, particularly any of those mentioned in the second column of the preceding list as characteristic of fallow fields, together with other herbaceous perennials such as *Fragaria virginiana, Trifolium repens,* and *Antennaria neodioica.* Species of *Cladonia* and *Polytrichum* also are usually present here; sometimes the ground cover consists almost wholly of *Polytrichum* and *Leontodon.*

The general aspect of the vegetation, as just described, is xerophytic. Under favorable edaphic conditions, however, it may be much more mesophytic. In moist meadows the grass forms a denser growth and is made up largely of species such as *Poa pratensis, Agrostis alba,* and *Anthoxanthum odoratum.* Common associates of the grasses here are *Euphrasia purpurea* Reeks and *Rhinanthus Crista-galli.* The *Euphrasia* occupies much the same ecological position in the fields of northern Cape Breton as does *Houstonia caerulea* in those of southern New

FIGURE 34.—Abandoned field with white spruce and *Dicksonia;* Barrasois.

England. Any of the perennial herbs referred to above may grow in moist meadows, but here, in addition, pronounced mesophytes, such as the orchids, *Habenaria clavellata, H. lacera,* and *H. psycodes,* are also frequent.

Whenever a field is permitted to run wild, *Dicksonia punctilobula* (FIG. 34), *Pteris aquilina, Anaphalis margaritacea,* and other herbaceous perennials which grazing or haying have held in check tend to assert themselves, while various shrubs may also become conspicuous. Among the latter, *Juniperus communis depressa, Rubus idaeus canadensis* and *Vaccinium pennsyl-*

vanicum are common in neglected pastures, while *Salix humilis, Alnus mollis* and *Spiraea latifolia* are frequently prominent. But while *Dicksonia* and other herbs often develop luxuriantly, and while shrubs may sometimes come to predominate over considerable areas, on the whole there is no sharply defined intermediate successional stage between grassland and coniferous forest. As a matter of fact, trees are present from the outset.

FIGURE 35.—Reproduction of balsam fir and spruce in abandoned field, Barrasois.

A close examination of almost any grassy field will usually reveal the presence of numerous young seedling coniferous trees (FIG. 35). In the face of repeated mowing these trees will persist for several years and are ready, whenever the opportunity offers, to grow up and to more or less completely occupy the ground. Grazing may check tree reproduction but seldom prohibits it entirely. In one field where sheep are pastured much of the year, the writer counted as many as twelve seedling white spruces to the square yard. The browsing of cattle may check their growth and is responsible for various grotesque tree shapes,

but only frequent cutting will prevent trees from eventually gaining supremacy. The speed with which grassland may become superseded by woodland is suggested by the conditions observed in two quadrats (10 meters, 32.8 feet square), which were located in fields that had been neglected for twelve or fifteen years. In one case, counting only specimens which were more than a foot high, there were ninety trees in the quadrat, ranging up to twelve feet in height and thirteen years in age. Of these trees, thirty-four were white spruce, twenty-seven balsam fir, twenty-seven paper birch, and two white pine. In another similar quadrat there were fully five hundred trees, dead or alive, ranging up to fifteen feet in height and averaging between eight and fifteen years in age. In this case, the trees without exception were white spruce. These quadrats illustrate the varying composition which an old field woodland may possess. In some cases there will be nearly pure stands of white spruce, in others intimate admixtures of this tree with black spruce, balsam fir, and paper birch. In the vicinity of Baddeck, and in a few other localities noted, the tamarack, in many cases, rivals the white spruce for the position of prominence in abandoned pastures. The local frequency of the tamarack, as already suggested, is attributable, without much question, to soil conditions: indeed, it seems quite possible that the local distribution of this tree might prove of value as an indicator of the capabilities of land for crop production. It seems quite probable that variations in the composition of old field woodlands can be correlated still further with local differences in soil, etc., although, so far as the observations of the writer have extended, the variations might well be explained, in large measure at any rate, by the proximity of seed trees and the fortuitous distribution of seed.

The changes which accompany the development of woodlands in old fields can best be brought out by a specific illustration: a series of pastures along the Barrasois River which have been abandoned at different dates. The vegetation of the pastures themselves is essentially as described above. The pioneer trees are mostly white spruce. These germinate prolifically, especially in places where there is a carpet of *Polytrichum*. The moss carpet apparently furnishes an ideal seed bed, since in situations where it is absent reproduction is noticeably sparser. As the spruces mature, forming first a rather open grove (Fig. 36) and later

a closed forest, a sequence of changes may ensue similar to what has been described in connection with the later phases of the rock outcrop succession. By the time the grove phase has been attained, much of the pasture vegetation has vanished. In its place, in the semi-shaded, narrow lanes (or spaces) between the trees (or groups of trees), is a more or less continuous bed of moss, growing on which may be found the pioneer representatives of various woodland species of plants. The moss carpet at first may consist of *Polytrichum commune,* but soon this is

FIGURE 36.—Grove of white spruce in former pasture; Barrasois. Photograph by Dr. L. H. Harvey.

largely superseded by *Hypnum Schreberi.* Among the herbaceous woodland pioneers noted here are *Lycopodium complanatum, L. clavatum, Maianthemum canadense, Cornus canadensis, Viola incognita, Epigaea repens, Linnaea borealis americana,* and *Trientalis americana.* Small white spruce seedlings grow scattered over the moss carpet, but, practically speaking, white spruce reproduction has come to a standstill, for few of these seedlings are destined to mature.

In this connection, there is one feature of a young spruce forest that demands special comment. On the ground beneath

the trees in such a forest there may be no vegetation whatever, but only a dry layer of dead spruce needles, comprising what the forester familiarly refers to as "duff." The absence here of plants does not seem to be attributable directly to insufficient light. In remarking recently on this same phenomenon, Moore ('17, pp. 156, 157) has concluded that the lack of vegetation is due to the dryness of the soil which results from the interception of the precipitation by the crowns of the trees. The writer had already arrived at a conclusion somewhat as follows. During the development of a group of young spruces in the open, at first there is ample light for all. But later on, in the competition for light which ensues as they become larger, many of the trees are killed. The accumulation on the ground beneath, both of the needles which fall from these dead trees and of needles derived from the shaded branches of the living trees, may take place so rapidly that the ground vegetation is buried. The formation of this thick, loose layer of dry needles not only wipes out the original ground cover, but, because of its dryness, prevents any new vegetation from getting a start. This process, initiated while the tree growth is still open, continues during the transition from the grove to the forest stage in the succession. A layer of needles several inches thick may collect on the forest floor, and all the mosses and herbaceous plants, as well as the seedling trees described in the preceding paragraph, may be exterminated. The extreme paucity of vegetation on the forest floor which results in this manner is a very characteristic feature of young coniferous forests. Later on, as the forest matures, the trees becoming greatly decreased in number by the constant competition for light, and in consequence becoming more widely spaced, the rate of leaf-fall gradually slackens so that a certain degree of equilibrium is brought about on the forest floor. It then becomes possible for a new ground cover to establish itself: *Polytrichum commune* and *Hypnum Schreberi* reappear, followed shortly by *Hylocomium splendens,* and a moss carpet is gradually reëstablished, on which woodland herbs and shrubs, together with seedlings of balsam fir and other trees of the coniferous forest association-type become increasingly abundant. The history of the forest beyond the grove stage of the succession is practically identical with what has been described in connection with primary successions.

b. ASSOCIATION-COMPLEXES DUE TO FIRE

Fire, like cultivation, destroys the original vegetation and causes the institution of new successional series. According to the completeness of the devastation, particularly as it affects the humus layer with its subterranean plant organs and its micro-organisms, broadly speaking, two lines of succession may be distinguished: one where the humus has escaped serious injury, the other where the humus has been destroyed. Between these there of course are intermediate possibilities.

Humus little injured.—Let it be assumed that previous to the conflagration a burned area has supported a forest of the climax type. Aside from the annihilation of much of the antecedent vegetation, the most obvious immediate effect of fire is the removal of the forest cover and the consequent increased illumination of the forest floor. The revegetation of such an area is destined to be accomplished partly through the agency of plants which in various ways have survived the fire, partly through the invasion of plants from other sources. Almost the first after-effect of the fire is seen in the rapid spread of certain herbaceous species which were only sparingly represented in the original forest, but which are able to flourish in the new environment. *Cornus canadensis* perhaps nowhere develops more luxuriantly than in burned areas, while *Linnaea borealis americana* and *Maianthemum canadense* also thrive here. Of the shrubs and small trees in the burned forest, *Corylus rostrata, Acer spicatum* and *Viburnum cassinoides* frequently survive. The local herbaceous element in the flora may predominate for a longer or shorter period, but it is soon augmented by an extraneous element in which the following species are usually conspicuous: *Lycopodium clavatum* and *Gaultheria procumbens; Solidago bicolor* and *S. macrophylla; Pteris aquilina* and the "fire-weeds," *Epilobium angustifolium* and *Anaphalis margaritacea*, which frequently form a rank growth; and *Rubus idaeus canadensis*, which within a few years may produce an almost impenetrable tangle over the entire area.

In the reëstablishment of forests in burned areas of this sort, the paper birch, as elsewhere in the northwoods, is everywhere the conspicuous pioneer. This tree, it will be recalled, is sparingly represented in the regional climax forest. After a burn it reproduces rapidly, partly by means of coppice shoots from

stumps which have survived the fire, partly from seed, and with its rapid rate of growth it quickly gains the ascendancy over other trees in the rising forest. Red maple also frequently plays an active rôle in reforestation, reproducing in much the same manner as the birch; while the bird cherry and any of the poplars may be present in greater or less abundance. A point of interest, to be emphasized in this connection, is that the balsam fir, with the spruces, may appear at a very early stage

FIGURE 37.—Succession after a burn; balsam fir coming in under paper birch; northwestern Maine.

in the succession: in fact, their seedlings may be present from the outset. But, on account of their relatively slow growth in the shade cast by the birch canopy, the conifers continue to occupy a position of subordinate importance for many years (FIG. 37). By the time a hundred years has elapsed, however, a marked change in the character of the forest has taken place; for by this time the balsam fir has usually become the predominant tree. This latter phase in the succession is well illustrated by an old burn forest near Indian Brook. Here the bulk of the mature stand consists of balsam fir intermixed with

frequent white spruces, scarcely any of the balsams being more than ten inches in diameter. Paper birch is rarely present in the younger growth, but is represented abundantly by scattered older specimens ranging up to a foot and a half in diameter, while the ground beneath is strewn with the remains of fallen trees. Large red maples are frequent and one large hemlock with a healed fire scar was noted, obviously a relict of the former forest.

The ultimate association-type of the burn succession is a forest of the regional climax type, provided edaphic conditions

FIGURE 38.—View along coast north of Neil's Harbor: barrens and second growth forest, mostly white spruce; aspect largely the result of repeated burning. Photograph by Dr. L. H. Harvey.

are favorable to its development. Indeed, very often the beech and others of the climax trees beside those already mentioned may appear early in the series, arising either from coppice sprouts or from seed. It seems hardly necessary to describe the changes in the undergrowth which accompany the development of the forest.

Humus destroyed.—There are extensive tracts of land along the eastern coast of northern Cape Breton, particularly between North Bay, Ingonish and Aspy Bay (FIG. 38), which it is presumed were formerly covered, very largely at any rate, with deciduous forests, but which have suffered so severely from fires that at one time or another not only the greater part of the

vegetation, but most of the humus as well has been consumed. In areas of this sort succession must start all over again from near the bottom and a sequence of stages similar to what has been described in primary successional series may be observed. To be sure, succession in an area which has been denuded by fire differs in certain respects from a primary succession, owing chiefly to the fact that even repeated fires fail to completely annihilate all the previously existing humus and plant life, and

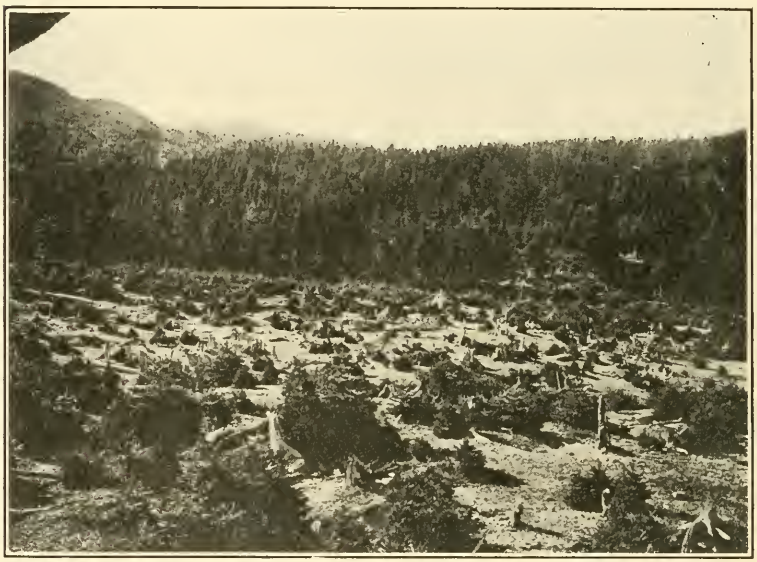


FIGURE 39.—White spruce reproduction in an area which has been repeatedly cut and burned; South Bay, Ingonish.

that the relicts which have thus survived may play an important part in the succession. But it is hardly worth while to attempt to depict the stages in detail. In general it may be stated that, just as in the case of primary successions, there is a marked variation in the nature of the primitive associations, due to local differences in the nature of the substratum, etc., but that all successional series tend to merge in the formation of forest.

Abundance of white spruce the result of fire and cultivation.— At the present day, throughout the region of deciduous forests, wherever tracts of land have been cultivated and then abandoned

or have been ravaged by repeated fires, white spruce, with local exceptions, is everywhere the most abundant tree of second growth forests. The explanation of this fact is obvious. The white spruce is essentially a pioneer. It seeds prolifically and rapidly colonizes open grounds of almost any description (Fig. 39). The effect of cultivation and fire in destroying the seedlings of balsam fir and other trees, which otherwise might have dominated, enables the spruce, with its capacity for rapid reproduction in the open, to establish itself and to make head-

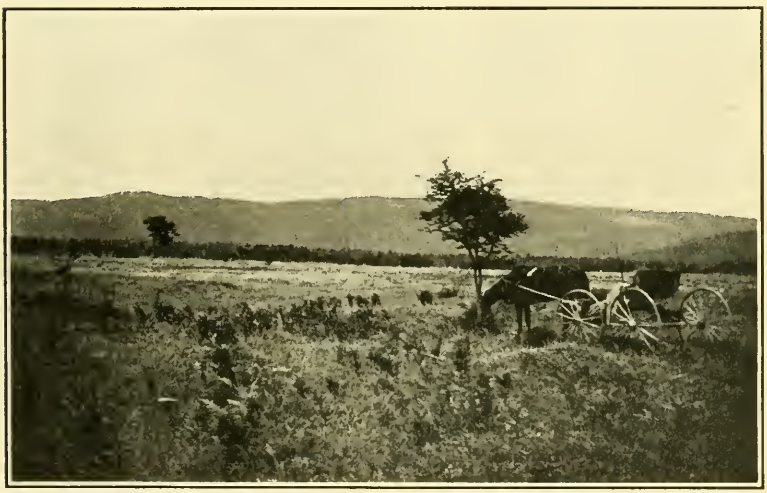


Figure 40.—Blueberry barren near Frizzleton.

way which otherwise would be impossible. The common practice of burning over woodlots in order to keep them open for pasturage or for some other reason, naturally favors the spruce. In brief, the combined effect of cultivation and fire is to arrest the succession, so that it rarely progresses beyond the pioneer forest stage.

Blueberry barrens.—Among the most unique features of the interior plateau of northern Cape Breton are the Barrens. These natural barrens, which will be described later, should not be confused with the barrens of the lowlands (Fig. 40), which are the result of repeated fires, usually set intentionally every few years in the interest of the blueberry crop. Extensive blue-

berry barrens of this sort are found in the Margaree district, where they may occupy hundreds of acres. The predominant plants in such tracts are the blueberries, *Vaccinium pennsylvanicum* and *V. canadense,* with which, though far less abundant, are associated other ericaceous shrubs, such as *Kalmia angustifolia, Vaccinium Vitis-Idaea, Gaultheria procumbens,* and *Ledum groenlandicum.* Various herbaceous plants occupy a prominent position, notably *Pteris aquilina, Danthonia spicata* and *Aster multiflorus,* while *Cladonia rangiferina* and the mosses, *Polytrichum commune, P. juniperinum,* and *Hypnum Schreberi,* are common. The ecological aspect is that of a heath, though there are scattered trees, mainly tamarack and white spruce. The balsam fir is virtually absent.

Left to itself, such an area becomes forested within a few years. The process of reclamation is graphically illustrated by one area examined, which adjoins a large heath, but is separated from it by a highway that has acted as a "fire line." This area is now occupied by an open forest of tamarack and white spruce. The balsam fir is absent from among the larger trees, but is abundantly represented in the young growth. The heaths are present in greatly reduced abundance, as compared with the barren area across the road, and the moss carpet has become correspondingly more luxuriant.

c. ASSOCIATION-COMPLEXES DUE TO LOGGING

The indiscriminate removal of the merchantable timber in a climax forest by logging usually has little effect on the future composition of the forest, provided the area escapes being burned over. Some trees, notably the paper birch and balsam fir, tend to become somewhat more abundant here, and frequently pioneer species such as the aspens are able to establish themselves temporarily in cut-over tracts. But, on the whole, the forest may be said to regenerate itself through the younger generation of trees which was present in the original forest. Where a forest is lumbered *discriminately,* as is frequently done for fir and spruce alone, it is of course obvious that the detailed physiognomy of the forest may be quite appreciably altered. Where the removal of the timber is followed by burning, most of the younger trees are destroyed and complete regeneration is

impossible. This latter point is well illustrated by conditions near an old settlement along Indian Brook, which has been deserted for many years. The climax forest was cut over in two adjoining tracts, one of which was afterward burned over, the other not. To-day, perhaps forty years after cutting, the unburned area is covered by a forest of yellow birch, sugar maple, and other climax trees, with scattered specimens of paper birch and large-toothed aspen (*Populus grandidentata*). The burned area, on the other hand, supports an almost pure forest of paper birch. In both forests the balsam fir is the most conspicuous undertree.

C. Primary Formations of the Hydrarch Series

1. The Formation-types of Lakes and Ponds Inland

a. Introductory

The ecological relationship of lakes and swamps.—For purposes of convenience, lakes and swamps are here treated under separate headings, but, broadly speaking, they belong to the same family and there is no sharp dividing line between them. Through the activity of various agencies a lake or pond may become filled in and converted into a swamp. The manner in which this transformation may be accomplished by plants, together with the changes in vegetation which accompany the process, is outlined in the following paragraphs, quoted, with slight alterations, from an earlier paper by the writer ('15, pp. 175–178):

> The important rôle commonly played by plants in the conversion of lakes into swamps has long been recognized. When the plants in a lake die, their remains sink to the bottom where, because of insufficient oxidation, the vegetable débris is only partially decomposed. In this way there collects on the floor of the lake a layer of vegetable muck, or peat; and through the continued addition of fresh layers the deposit is gradually thickened and built upward. This constructive process may go on until ultimately the surface of the deposit reaches the level of the water, when the lake gives way to a swamp. But the rate at which the substratum is built up and the length of time which elapses before it reaches the water level varies greatly in different parts of a lake. Plants grow most luxuriantly in shallow water; they may be practically absent from the deeper areas. It follows, therefore, that the accumulation of muck or peat proceeds much more rapidly in shallow than in deep water—so

much so, in fact, that the shoreward parts of a lake may have become completely filled in before any appreciable accumulation has taken place in the deeper areas. The filling in of deep lakes usually proceeds centripetally. This is due to the fact that the shoreward zones of vegetation, in consequence of their more vigorous growth, exhibit a tendency to push outward into deeper water. Where this tendency is pronounced, the shoal water zones may completely override the deeper water zones, at the same time causing the lakeward slope of the deposit to become much steeper. The filling in of the deeper parts of a lake may also be effected to a varying degree by the accumulation of loose débris from the adjoining shallows or by the deposition of sediment in flood time, while various plankton forms may contribute in a small measure to the deposit.

Coincident with the upbuilding of the substratum through the deposition of muck or peat, as outlined in the preceding paragraph, transformations occur in the character of the vegetation growing on the lake's bottom. For, as the depth of the water diminishes, it becomes possible for plants to develop which were unable to grow in the deeper water. And as these shallow water plants increase in number and abundance, they may crowd out and eventually replace the deeper water species. Thus there may follow one another a series of plant associations, each one of which, by helping to raise the bottom of the lake to a higher level, prepares the way for less hydrophytic associations, but at the same time, by so doing, brings about its own extermination.

It is a familiar fact that the plants which fringe the edges of so many lakes are commonly massed in more or less definite bands or zones that tend to be concentric with respect to the deeper parts of the lake. The floristic composition of these zones in any given lake is determined largely by the ecological requirements of the various species of plants which happen to be present, in relation to the depth and clearness of the water . . . Reference has already been made to the succession of plant associations which accompanies the building up of the lake bottom. It has been found that this dynamic Vertical Succession corresponds closely with the apparently static Horizontal Zonation just outlined . . . . . This general coördination between the contemporaneous horizontal sequence of zones and the historical or vertical order of succession has been verified repeatedly by the stratification of plant remains observed in peat deposits, and is of great assistance in reconstructing the past or predicting the future course of events in any specific locality.

Of course, not all swamps have originated in the manner just described (see further under head of swamps); neither, on the other hand, do all lakes exhibit any pronounced tendency to become converted into swamps. For reasons which are not always clear, there is the greatest variation in the speed at which the transformation is brought about, and in many lakes, not only does there seem to be scarcely any tendency toward swamp

formation, but little change would appear to have taken place at any time since their formation.

Geological and other factors influencing the distribution and vegetation of inland lakes.—The majority of the lakes and ponds in the lowland of northern Cape Breton are glacial: they occupy depressions which have resulted from glacial activity (see further discussion in Nichols '15, pp. 170–171). In calcareous districts, however, particularly in localities where there are

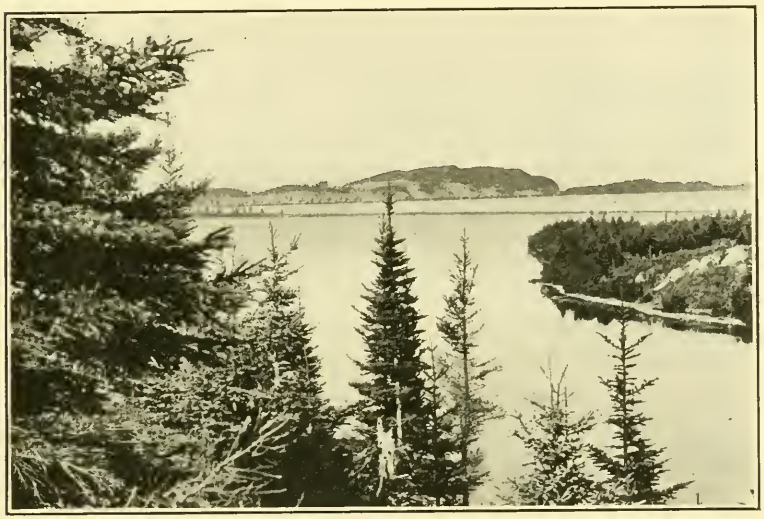


FIGURE 41.—Freshwater Lake, South Bay, Ingonish; cut off from ocean by a shingle beach; in distance, Middle Head, mostly granitic; in right foreground, a gypsum outcrop; second growth forests of white spruce and balsam fir. Photograph by Dr. L. H. Harvey.

extensive deposits of gypsum, "sink holes" due to subterranean erosion are common, and these frequently are occupied by ponds. Still a third type of water basin, due entirely to vegetative activity, is encountered on the plateau, and will be described in some detail later.

In their influence on the vegetation of lakes and ponds, drainage and permanency are factors of considerable significance. The effect of drainage will be discussed presently in connection with the formation-types of swamps. The effect of permanency is seen in comparing the vegetation of permanent, with that of

periodic, lakes or swamps. Permanent and periodic lakes and swamps, as related to topography and ground water level, have been fully discussed in the writer's paper referred to above ('15, pp. 172–175).

b. THE ASSOCIATION-COMPLEXES OF WELL-DRAINED LAKES AND PONDS

The association-types of permanent lakes.—Freshwater Lake (Fig. 41) and Warren Lake, at Ingonish, may be taken as representative examples of fairly large, well-drained lakes. Except for *Chara* and various algae there is little vegetation below a depth of six feet. The majority of aquatic plants grow best in water less than three feet deep. Along sandy shores, which are the prevailing type in both ponds, the following aquatic species are more or less abundant.

Chara sp.
Fontinalis sp.
Isoëtes echinospora Braunii
Sparganium angustifolium
Potamogeton Oakesianus
Potamogeton heterophyllus
Potamogeton bupleuroides
Glyceria borealis
Scirpus subterminalis
Eleocharis palustris vigens
Scirpus americanus
Juncus militaris
Nymphaea advena
Ranunculus Flammula reptans
Myriophyllum humilis
Nymphoides lacunosum
Eriocaulon septangulare
Lobelia Dortmanna

Nymphaea and *Nymphoides* are the commoner forms in the deeper shallows. *Eriocaulon* often forms a bright green carpet on the bottom in water three or more feet deep, but seldom flowers where it is more than a foot deep: *Ranunculus* forms similar carpets in shallow water, but flowers only on the shore. In places *Juncus* and *Isoëtes* grow in profusion. But for the most part the sandy bottom is only sparsely covered by vegetation. It might be added that *Carex aquatilis,* not noted in either of these lakes, is a frequent form along the shores of lowland lakes, locally giving rise to marshy marginal swamps similar to those to be described later in connection with lakes in the highlands.

The narrow sandy beach, between high and low water marks, supports a scanty growth of herbaceous species, among them

Equisetum arvense, Juncus articulatus, and *Ranunculus Flammula reptans.* Above high water mark there is ordinarily a fringe of *Myrica Gale* (nearest the water) and *Alnus incana.*

Muddy shores are developed to some extent in sheltered situations. Here the aquatic vegetation includes most of the species already listed, and in addition *Utricularia intermedia* and *U. vulgaris.* Certain other species, mostly amphibious, grow in

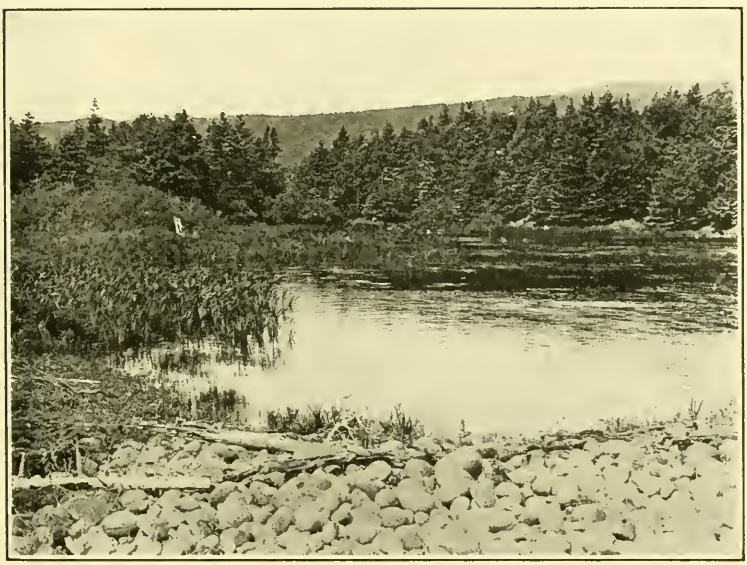


FIGURE 42.—Fresh pond behind shingle beach, well drained by seepage through barrier; *Typha latifolia* in left foreground; Barrasois.

shallow water or on the mucky shore, which is swampy at low water. These latter include: *Sphagnum* sp., *Drepanocladus fluitans, Dulichium arundinaceum, Iris versicolor, Potentilla palustris, Hypericum virginicum, Sium cicutaefolium,* and *Lysimachia terrestris.* As along sandy shores, the sweet gale and alder fringe the shore at high water mark. Along sandy shores there is little evidence of succession, but along muddy shores there is a tendency for swamps to develop.

The association-types of permanent ponds.—Small ponds (FIGS. 26, 42) may differ little from lakes in the character of

their vegetation. But, on the whole, aquatic plants are apt to be relatively more abundant here by reason of the lesser depth of the water, its comparative quietness, etc. Largely because of the absence of any appreciable amount of wave action, the shores of small ponds tend to be more muddy than those of the larger bodies of water. The vegetation of sandy shores is similar to what has been described above, and the same is true in general of muddy shores. Here, however, there is often a rank growth of cat-tails (*Typha latifolia*) and bulrushes (*Scirpus occidentalis, S. cyperinus, S. atrocinctus,* etc.), through the activity of which the pond tends to become filled in and converted into a swamp.

Sink-hole ponds frequently exhibit the phenomenon of marl-formation (see Nichols '15, pp. 194–196). In such ponds there is usually a luxuriant growth of *Chara,* one of the most important marl-forming plants, and of various algae. Among the prominent aquatic seed plants here may be *Potamogeton pectinatus* and *P. pusillus.* Leaves and stems of all submersed forms are usually incrusted with a thin, whitish, flaky deposit of marl.

The association-types of periodic ponds.—Periodic ponds are not sharply delimited from permanent ponds on the one hand or from periodic swamps on the other. Very shallow depressions, which during the growing season contain water for only a brief period, are commonly occupied by a rank growth of such species as *Scirpus cyperinus* and *S. atrocinctus, Juncus effusus* and *J. brevicaudatus,* and *Iris versicolor.* In the case of ponds which disappear completely only for a short period during the summer, there may be a striking concentric zonation of plant associations. In one instance, for example, the wetter central area is largely occupied by the moss, *Amblystegium riparium.* Proceeding from here toward high water level there are encountered (*1*) a zone of more or less amphibious species such as *Sparganium americanum, Juncus effusus, Ranunculus Flammula reptans, Hypericum canadense, Lysimachia terrestris,* and *Sium cicutaefolium;* (*2*) a zone of *Iris versicolor;* (3) a zone of *Alnus incana.* Elsewhere *Eleocharis palustris* and the species cited earlier in this paragraph may be prominent as marginal plants, while in some cases the liverwort, *Marchantia polymorpha,* develops profusely on the muddy shores of periodic ponds.

c. THE ASSOCIATION-COMPLEXES OF UNDRAINED LAKES AND PONDS

The association-types of permanent ponds.—Sink-hole ponds commonly have no visible outlet and are practically undrained. Aquatic vegetation as a rule is luxuriantly developed here, but varies greatly in its floristic composition, even in neighboring ponds. In one small pond, for example, *Potamogeton natans* is practically the only species present; in another, *Chara;* in another, *Fontinalis gigantea;* while in still another, *Chara, Fontinalis gigantea,* and *Potamageton pusillus* grow intermixed. Such ponds fluctuate more or less in level from season to season and the marginal vegetation resembles that of periodic ponds.

Of particular interest, in view of their subsequent history, are the undrained ponds in which originate peat bogs. The water in these fluctuates very little in level from season to season, and while the ponds may be small in area they are usually fifteen or more feet in depth. Depressions of this sort are by no means common near the coast, and most of those which were discovered had already attained the bog stage in their development. It is of interest to note, however, that the pioneer vegetation in and about these ponds is similar in most respects to that of other ponds. The aquatic vegetation includes *Nymphaea advena,* species of *Potamogeton,* and various aquatic mosses and algae. *Chara,* however, seems to be rare or absent. In the shallow water near the margin may grow *Sparganium americanum, Eriocaulon septangulare, Carex Pseudo-Cyperus, Potentilla palustris,* and *Lobelia Dortmanna.* Along the more or less mucky shores may occur herbaceous species, such as *Onoclea sensibilis,* various sedges, *Iris versicolor, Lysimachia terrestris, Hypericum virginicum,* and *Lycopus americanus;* and shrubs, such as *Myrica Gale, Alnus incana, Rosa nitida,* and *Ilex verticillata.* The most striking difference between these and ordinary ponds is seen in the frequently luxuriant development of various species of *Sphagnum,* the significance of which will be pointed out later. The marginal shrubs here also commonly include *Chamaedaphne calyculata* and *Kalmia angustifolia,* both of which are typical bog forms.

The association-types of periodic ponds.—Periodic undrained ponds scarcely differ in their vegetation from periodic well-

drained ponds, since essentially the same end is accomplished through the periodic drying up of the pond as might be attained through drainage. They therefore require no special comment.

2. The Formation-types of Lake- and Spring-swamps Inland

a. INTRODUCTORY

Lake-, spring-, and precipitation-swamps.—Swamps which have originated in the manner described earlier, through the filling in of lakes by vegetation, may be designated *Lake-swamps.* Many swamps, however, probably the majority of those in the lowland, owe their existence to the relation between topography and ground water level, i. e., to the presence of spring or seepage water. Such swamps may be designated *Spring-swamps* (see Nichols '15, pp. 184, 192). Lake- and spring-swamps are widespread in their distribution throughout most regions. In regions like the one under consideration, where precipitation is high and the evaporating power of the air low, there is still a third type of swamp whose existence is dependent very largely on direct atmospheric precipitation. Swamps of this sort, well exemplified by the raised bogs of the high interior plateau, may be designated *Precipitation-swamps.*

The ecological significance of drainage.—In his study of the geographical distribution and ecological relations of bog associations in eastern North America, Transeau ('03, p. 420) arrived at the conclusion that "the 'drained swamp' and 'undrained swamp' classification will not hold over any great area." Drainage, however, has been employed as a basis of classification by Cowles ('01, pp. 145–156) and others, and it is the conviction of the writer that, from the standpoint of physiographic ecology, this factor affords by far the most fundamental criterion yet conceived, at least for the classification of the lakes and swamps in the inland group. The relationship between cause and effect may often be obscure, since the influence of drainage is commonly expressed indirectly through other, more direct factors; but, in the last analysis, drainage, more than any other single factor or set of factors, seems to have a vital influence on the vegetation, through its effect on the aeration of the soil and on the accumulation therein or removal therefrom

of various deleterious substances, as well as on other peculiarities of the substratum with which the character of the vegetation may be more directly correlated (in this connection, see Rigg '16; also Harper '18, pp. 27–31).

Drainage as a basis of classification.—In treating the lakes and swamps of the inland group in northern Cape Breton, drainage has been selected as the most fundamental basis of classification. On this basis the lakes and ponds have been divided into two groups, well-drained and undrained, and the swamps into three, well-drained, poorly drained, and undrained. The practical application of any scheme of classification of course has its limits, owing to the difficulty, if not the impossibility, of adequately correlating cause and effect, and whatever factors are selected as criteria, all sorts of intergrading conditions are encountered. Particularly in the case of swamps is the complexity of the situation enhanced in a cool, humid region such as this by the fact that atmospheric factors may react on the vegetation in such a manner as to neutralize to a greater or less degree the influence of dissimilar edaphic conditions.

During the course of the present investigations in northern Cape Breton, the writer has examined several hundred different lakes and swamps. In a number of the swamps, in addition to observations on the surface conditions, soundings were taken with a fifteen foot iron rod (summer of 1915). By this means it was possible (*1*) to ascertain the depth of the underlying vegetable deposit; (*2*) by the attachment of a Davis peat-sampler (see Bastin & Davis '09, p. 61), to determine the character of the deposit at different depths; and (*3*) with the aid of a hand-level, to figure out the topography of the underlying terrain, with particular reference to its bearing on the drainage problem and also its general relation to the surface of the swamp.

Well-drained and undrained swamps compared.—In their typical development, well-drained and undrained swamps differ from one another in several important respects. (*1*) Well-drained swamps are best developed on springy slopes, where the gradiant is sufficiently steep to insure adequate drainage. They also commonly occur along the banks of streams (many such swamps, more especially along small brooks, are better included with the swamps of the inland group than with those of the river group). Undrained swamps, as exemplified by bogs,

ordinarily are best developed in relatively deep, undrained or poorly drained, water filled depressions. For reasons which will be apparent later, however, in humid regions, like the one under discussion, swamps of the undrained type are by no means confined to depressions. (*2*) Both well-drained and undrained swamps may be underlain by peat; but in the former the deposit usually is quite shallow and sometimes it is entirely absent. Moreover, in well-drained swamps the peat as a rule is mucky, the plant remains being pretty thoroughly decomposed. Undrained swamps invariably are underlain by peat deposits, which often exceed fifteen feet in thickness; the peat is more or less spongy, and the plant remains for the most part are well preserved. (*3*) The soil in practically all swamps in northern Cape Breton is acid to litmus, but it is appreciably more so in swamps of the undrained type than in others. (*4*) The vegetation of well-drained swamps is characterized by the moderate abundance of the sphagnums; by the great variety of herbaceous seed-plants, which in large part are hydrophytes; by the scarcity of ericaceous shrubs; and by the presence of several deciduous trees of southward distribution. The vegetation of undrained swamps, on the other hand, is characterized by the luxuriant development of the sphagnums; by the comparatively small number of species of herbaceous seed-plants, which in large part are bog xerophytes; by the abundance of ericaceous shrubs; and by the absence of practically all trees except the black spruce and tamarack.

b. THE ASSOCIATION-COMPLEXES OF WELL-DRAINED SWAMPS

Pioneer association-types.—Among the important pioneers in the development of vegetation on springy or wet slopes are the bryophytes, notably the following species:

*Marchantia polymorpha**	*Sphagnum squarrosum*
*Pellia epiphylla**	*Philonotis fontana**
*Pallavicinia Lyellii**	*Mnium punctatum**
*Scapania nemorosa**	*Brachythecium novae-angliae*

Of the herbaceous vascular plants, almost any of the species to be listed later as characteristic of wet meadows may appear at a very early stage in the succession, but the following list

includes the forms which, on the whole, are more prominent as pioneers:

*Onoclea sensibilis**	*Juncus effusus*
Equisetum sylvaticum	*Iris versicolor**
Glyceria canadensis	*Sagina procumbens**
Glyceria laxa	*Cardamine pennsylvanica**
Scirpus atrocinctus	*Drosera rotundifolia*
Scirpus rubrotinctus	*Chrysosplenium americanum**
Carex crinita	*Hypericum canadense*
*Carex scabrata**	*Epilobium palustre*
Carex stipata	*Lysimachia terrestris*
*Juncus articulatus**	*Lycopus americanus*
Juncus brevicaudatus	*Mentha arvensis**

Association-types of open swamps.—The luxuriant growth of the grasses, sedges, and rushes may result in the development of a wet meadow association-type, characterized by the predominance of grass-like growth-forms and the relative absence of woody plants. During the evolution of the wet meadow, the plant cover gradually becomes denser, while the nature of the substratum may become modified through the formation of a layer of mucky peat. Contemporaneously with these changes, many of the pioneer species (notably those starred [*] in the above lists), either disappear or else become restricted in their distribution to the more open, wetter habitats. Others become more abundant, and at the same time still other species not before represented may make their appearance. The following list includes various herbaceous plants, which, in addition to those already mentioned, and together, less frequently, with those to be given in a subsequent list, commonly are more or less abundantly represented in open, well-drained swamps.

Aspidium Thelypteris	*Habenaria dilatata*
Aspidium cristatum	*Habenaria psycodes*
Osmunda cinnamomea	*Thalictrum polygamum*
Osmunda regalis	*Fragaria virginiana*
Agrostis hyemalis	*Geum rivale*
Calamagrostis canadensis	*Sanguisorba canadensis*
Eriophorum virginicum	*Chelone glabra*
Carex canescens disjuncta	*Galium palustre*

Carex flava
Carex intumescens
Carex pallescens
Carex paupercula
Carex stellulata
Habenaria clavellata
Eupatorum purpureum
Aster nemoralis
Aster puniceus
Aster radula
Aster umbellatus

The bryophytes, as a rule, are well represented in open swamps, usually forming a more or less conspicuous understory of vegetation. The following additional species may be mentioned as characteristic:

Sphagnum palustre
Sphagnum imbricatum
Sphagnum magellanicum
Sphagnum Girgensohnii
Camptothecium nitens
Rhytidiadelphus squarrosus
Chrysohypnum stellatum
Acrocladium cuspidatum

More often than not, shrubs put in their appearance so early that the wet-meadow stage in the succession is of very brief duration. Frequently it is eliminated as a distinct phase. Instead, there may arise a mixed growth of shrubs and herbaceous plants: these with scattered trees constitute the most familiar type of vegetation in open swamps. The common pioneer shrub is the alder (*Alnus incana*). Associated with this may grow any (or all) of the following species:

Salix humilis
Myrica Gale
Ribes hirtellum
Spiraea latifolia
Rubus pubescens
Rubus canadensis
Rosa nitida
Ilex verticillata
Viburnum Opulus americanum
Viburnum cassinoides

On the whole, ericaceous shrubs (or semi-shrubs) are scarce in well-drained swamps, but *Chiogenes hispidula* commonly, *Kalmia angustifolia* frequently, and *Chamaedaphne calyculata* and *Vaccinium macrocarpon* occasionally are present.

The edaphic climax association-type.—Ultimately the entire swamp may become wooded, but, as a rule, much of it remains fairly open, with trees scattered, but more abundant toward the margin, and with the shrubs and herbaceous plants of open swamps occupying the spaces between them. The predominant trees, as a rule, are balsam fir, black spruce, white spruce, and

red maple; but associated with these, in varying abundance, may grow paper birch and yellow birch, white ash and black ash (*Fraxinus nigra*), and occasionally white pine.

The vegetation of wooded swamps may include various of the herbaceous and shrubby species already listed, but in addition to these a number of forms occur here which have not yet been mentioned, although some of them may likewise grow in open swamps. Such, for example, are the following:

Phegopteris polypodioides
Aspidium noveboracense
Osmunda Claytoniana
Taxus canadensis
Carex trisperma
Carex tenella
Carex leptalea
Carex folliculata
Clintonia borealis
Maianthemum canadense
Coptis trifolia
Mitella nuda
Oxalis Acetosella
Viola renifolia
Circaea alpina
Cornus canadensis
Linnaea borealis americana
Aster acuminatus

c. THE ASSOCIATION-COMPLEXES OF UNDRAINED SWAMPS

Occurrence of bogs along the coast.—In the vicinity of Baddeck and in other localities where the clayey nature of the soil retards drainage, bogs may develop in shallow depressions of any description. They develop best, however, here as in regions farther south, in fairly deep, closed, water-filled depressions. Raised bogs, such as occur along the coast in New Brunswick (see Ganong '98), and which are extensively developed on the interior plateau in northern Cape Breton, are apparently absent along the coast. The finest series of bogs discovered in the lowland is situated near the mouth of the Barrasois River, where in a tract of woodland less than a square mile in area there are six or eight fine examples. All of these occupy closed basins, presumably kettle holes in the drift, but possibly drift-covered sink holes, range in size from less than one to more than three acres, and bear a remarkable resemblance to certain Connecticut bogs (see Nichols '15, pp. 202–217). The following observations relate more particularly to this collection of bogs, which can be regarded as representative.

The floating mat and its association-types.—The early stages of bog development are best exhibited in the largest of these

bogs, where, at the south end, there still remains a pond some sixty feet long by twenty-five feet wide (Fig. 43). The filling in of such a pond is accomplished through the intervention of a floating mat, and the general features of mat formation are quite similar to what the writer has described for Connecticut bogs ('15, pp. 196–202). Its formation is brought about through the combined activity of shrubs, sedges, and sphagnums. Very

Figure 43.—Bog near mouth of Barrasois River; *Nymphaea* in foreground; sedge–shrub–sphagnum mat in middle distance; bog forest in center background.

commonly the forerunner of mat formation is the cassandra (*Chamaedaphne calyculata*). This shrub occurs both along the shore and along the edge of the advancing mat and frequently grows out several feet into the open water. Its relation to the mat is similar to that of the steel framework to a concrete building: it forms a skeleton upon which the sphagnum may be supported. The necessity for such support will be pointed out in the next section. Where, as is commonly the case, the cassandra is followed by a dense growth of sphagnum, a mat is

developed. Where, however, as along the south shores of several of these bogs, shade conditions preclude the growth of the sphagnums, no mat is developed (see further on p. 363). So luxuriant, as a rule, is the development of the sphagnums that the important rôle played by the cassandra is liable to be overlooked; but if a newly formed "sphagnum mat" be dug into, the woody ribs formed by this shrub will usually be found.

In some instances, certain sedges play a rôle similar to that just ascribed to the cassandra. Certain of these, e. g., *Carex filiformis,* in contrast to the shrubs, are quite capable of forming a mat themselves, independently of any assistance from the sphagnums. But, as a rule, the sphagnums make their appearance at an early stage in the history of the mat and thereafter play an important part in its development: ordinarily they spread so rapidly and grow with such luxuriance as to quickly become the predominant element of the plant cover. Various features associated with the formation and growth of floating mats are discussed further in the following paragraphs and in later pages, in connection with the swamps of the highland.

On the "sphagnum mat" thus formed, in greater or less abundance, grow various sedges and shrubs which, by their roots, rhizomes and trailing stems, tend to bind together and consolidate the otherwise loose structure. Characteristic species are the following:

Eriophorum callitrix
Eriophorum virginicum
Rynchospora alba
Carex canescens disjuncta
Carex paupercula irrigua
Carex stellulata
Kalmia polifolia
Ledum groenlandicum
Vaccinium macrocarpon
Vaccinium Oxycoccus
Menyanthes trifoliolata

Along the wet margin of the mat, where it borders on the marginal ditch (see further below), and in the ditch itself where this is swampy, commonly grow various forms which one ordinarily associates with well-drained swamps; among them: *Sparganium americanum, Iris versicolor, Alnus incana, Myrica Gale, Rosa nitida, Ilex verticillata, Hypericum virginicum, Lysimachia terrestris,* and *Lycopus americanus.* These plants seldom occur in the older parts of the bog.

The sphagnums in relation to the formation of floating mats.—The relatively subordinate rôle played by the sphagnums in initiating the formation of floating mats was suggested by Ganong ('03, pp. 440–441) and Transeau ('05-'06, p. 363), and has been emphasized by Davis ('07), Cooper ('13) and others. From these and the writer's observations it seems certain that in general the appearance of the sphagnum is subsequent rather than antecedent with reference to that of the vascular plants. The inability of the sphagnums of themselves to form a mat may be attributed largely to the lack of coherence and buoyancy in the mass of floating vegetation which they sometimes form. But added to this is the fact that comparatively few species of sphagnum are capable of flourishing with their foliage completely submerged. Of course there are certain sphagnums which are distinctly aquatic in their mode of growth, but among the twenty species which have been recorded from Cape Breton, only two definitely belong in this category, namely, *S. Pylaisei* and *S. cuspidatum* (see in this connection the ecological classification of bog sphagnums on p. 422). In many mountain ponds these two species grow in great profusion, floating at or just below the surface of the water, and their ecological relations there will be discussed in some detail later (see especially pp. 424, 429), Neither of these two species, however, occurs in any abundance along the coast: in fact, the writer has never seen *S. Pylaisei* except in the mountains, while *S. cuspidatum,* though frequently represented in lowland ponds by the var. *Torreyi,* is seldom of ecological importance here. The important mat pioneers among the sphagnums in the Barrasois bogs, which may be regarded as representative of lowland bogs in general, are *S. papillosum, S. magellanicum,* and *S. recurvum.* These three species grow best in very wet situations, but they will flourish only where the nature of the substratum is such that, at least throughout most of the growing season, their shoots remain partially raised above water level. The maintenance of this position they are not sufficiently buoyant to accomplish themselves, so that the preexistence of some sort of a support to prevent their sinking below the surface is essential. Hence the importance of shrubs and sedges as pioneers in the development of a "sphagnum mat."

The marginal ditch and its significance.—The formerly water-filled depressions now occupied by the Barrasois bogs have

become almost completely filled in through the activity of vegetation. All that remains in most cases to remind one of the pond stage in the succession is a moat-like marginal ditch or fosse, which averages perhaps ten feet in width and up to two or more feet in depth, which may be open and filled with water or occupied by a wet sphagnous swamp, and which, as a rule, more or less completely encircles the area occupied by the bog proper. The significance of this marginal ditch is not wholly clear. Elsewhere ('15, pp. 207, 208), the writer has been inclined to uphold the explanation first suggested by Davis ('07, pp. 150, 151), which attempts to correlate it with fluctuations in water level. But conditions here in northern Cape Breton are even better explained by Atkinson's theory ('05, pp. 615, 616) that the formation of the ditch is due to the shade produced by the forest along the shore, which hinders or prevents the growth of the mat-forming plants. In several of the forest-encircled Barrasois bogs the ditch is open along the southern shore, i. e., along the shore where the effect of the shade produced by the fringing forest naturally would be most pronounced, while along the northern, least shaded shore it has become completely filled in by vegetation. This condition obviously cannot be explained by the fluctuation theory; and for that matter, as already mentioned, there is very little seasonal fluctuation in water level in these basins.

Development of the edaphic climax association-type.—Beyond the wet bog stage, further development is largely dependent on two species of *Sphagnum* which have not as yet been mentioned: *S. fuscum* and *S. capillaceum tenellum,* particularly the former. Where the hydrophytic (or relatively mesophytic) pioneer sphagnums are superseded by these relatively xerophytic forms, the surface of the bog may become built up a foot or more above water level. In a mature bog the sphagnums almost everywhere are the predominant plants underfoot. They cover the ground with a continuous, hummocky, mattress-like carpet, which consists for the most part of the russet-green *S. fuscum,* interspersed with occasional more or less extensive patches of the reddish *S. capillaceum tenellum.* Commonly growing along with the sphagnums, in the older parts of the bog, are two mosses: *Polytrichum commune* and *P. juniperinum,* while in some of the higher, drier areas the sphagnums may have become superseded by cladonias or by such bryophytes as *Ptilidium ciliare* and

Hypnum Schreberi. Here and there, even in an old bog, there are moist or wet depressions in which may occur the more hydrophytic species of *Sphagnum,* together with liverworts such as *Cephalozia fluitans* and *Mylia anomala* and mosses such as *Calliergon stramineum* and *Drepanocladus fluitans.*

Scattered about over the sphagnum substratum, and varying greatly in abundance locally, are diverse trees, shrubs, and herbaceous plants. The characteristic and omnipresent tree of bogs is the black spruce. Invariably dwarfed in size, it commonly forms low, scraggly clumps, the result of layering followed by the death of the parent tree or of the original trunk.[11]

The predominant bog shrubs are ericads: *Chamaedaphne calyculata, Gaylussacia baccata, Kalmia angustifolia, K. polifolia,* and *Ledum groenlandicum,* to which should be added the semi-shrubby forms, *Chiogenes hispidula* and *Vaccinium Oxycoccus.* Three non-ericaceous shrubs also are usually well represented: *Amelanchier* sp., *Nemopanthus mucronata,* and *Viburnum cassinoides.* The most important herbaceous species are *Osmunda cinnamomea, Eriophorum callitrix, E. virginicum, Rynchospora alba, Carex trisperma Billingsii,* and *Cornus canadensis.* Three orchids, *Habenaria blephariglottis, Pogonia ophioglossoides,* and *Calopogon pulchellus,* are conspicuous when in flower; *Drosera rotundifolia* is common, and *Lycopodium inundatum* occasional in moist depressions; *Smilacina trifolia* occurs locally in wet places; *Empetrum nigrum* grows abundantly in the drier portions of one bog; while *Arceuthobium pusillum* is a frequent parasite on the black spruce.

d. THE ASSOCIATION-COMPLEXES OF POORLY DRAINED SWAMPS

Under the head of poorly-drained swamps are classed swamps of an intermediate character: swamps whose vegetation resembles in some respects that of well-drained swamps, in other respects that of undrained swamps. Boggy swamps of this character are of far more general occurrence than are those of the more extreme types, such as have been described in the foregoing paragraphs.

[11] Ganong ('97: see quotation on p. 447 of the present paper) has called attention to layering as a means of reproduction in *Picea mariana,* and the phenomenon has been discussed in some detail by Cooper ('11) and Fuller ('13).

Illustrative examples.—The general situation in poorly drained swamps is unusually well illustrated by a group of small swamps on Broadcove Mountain, which were studied in some detail. These swamps occupy a series of very shallow, trough-like depressions, which cross approximately at right angles the road from Ingonish to Neil's Harbor. Three of them, which may be designated respectively as swamps *A*, *B*, and *C*, are roughly represented in longitudinal section in FIG. 44. The surface slope, depth of peat, etc., were determined by means of sounding-rod and level. All three swamps have outlets at the lower end, and swamp *A* has a small brooklet traversing perhaps half its length. At the time they were studied (August, 1916), the out-

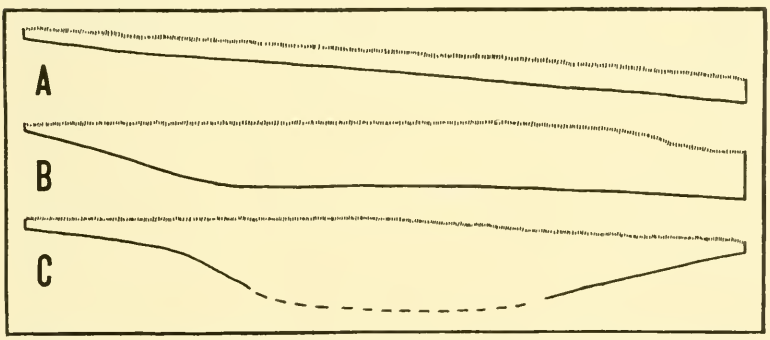


FIGURE 44.—Diagrammatic longi-sections of poorly drained swamps on Broadcove Mountain, north of Ingonish: see text.

lets in swamps *B* and *C* were dry, but a small amount of water was trickling out of *A*.

Swamp *A*.—This swamp is the least boggy of the three. Genetically it represents a condition which presumably obtained at an earlier period in the development of swamp *B*. In area it is about 300 feet long by 100 feet wide. In proceeding from its upper to its lower end, the ground slopes gently, dropping at the rate of about 1 : 50. Over almost the entire tract a layer of peat from two to two and a half feet in thickness has been formed. The aspect of the vegetation over much of the area is that of a meadow: *Scirpus hudsonianus* and *S. caespitosus* with species of *Sphagnum* form the bulk of the plant cover. Scattered over the meadow are various herbaceous plants, shrubs, and trees, *Osmunda regalis* in particular of the herbs forming considerable

patches locally. Along the margin of the swamp is a fringe of swamp forest. Floristically the vegetation of this swamp resembles in many respects that of an ordinary well-drained swamp. The majority of the vascular plants present there are also represented here, but they are relatively much less abundant. *Myrica Gale* is perhaps the commonest shrub in the open part of the swamp, and there are present here three shrubs not previously listed: *Pyrus arbutifolia atropurpurea, Rhamnus alnifolia,* and *Lonicera caerulea.* The boggy nature of the swamp is suggested by the presence of such plants as the two species of *Scirpus* mentioned, *Rynchospora alba, Smilacina trifolia, Sarracenia purpurea, Vaccinium Oxycoccus,* and *Lobelia Kalmii,* as well as by the luxuriant growth of the sphagnums. The dissimilarity between this swamp and a bog is emphasized, among other things, by the presence among the marginal woody forms of *Taxus canadensis, Acer rubrum, Fraxinus americana* and *F. nigra.*

Viewed from a genetic standpoint, it seems apparent that the area formerly occupied by the swamp vegetation was much more restricted than that which it occupies to-day. Originally long and narrow, as the surface has become built up through the accumulation of peat the swamp has spread out laterally, encroaching on the adjoining forested areas. Evidences of quite recent encroachment were noted just above where the swamp crosses the road. Among the pioneer seed plants, to judge from a relict colony near the lower end of the swamp, were *Calamagrostis canadensis, Juncus brevicaudatus,* and *Iris versicolor;* but the upbuilding of the surface and the lateral expansion of the swamp have been largely attributable to the luxuriant growth of the sphagnums and of the two sedges, *Scirpus hudsonianus* and *S. caespitosus.* It may well be said that the nature, and indeed the very existence, of the swamp as it is to-day is closely correlated with the activity of the compact mass of peat thus formed and of the superimposed plant cover in obstructing the drainage and thereby conserving the water supply.

Swamps *B* and *C*.—Swamp *B,* from a genetic standpoint, may be regarded as representing a later stage in the developmental series than swamp *A.* Conditions in swamp *B* have been more favorable to peat accumulation than in swamp *A,* owing to the more level nature of the terrain, and over much of the area the deposit of peat is more than six feet thick. It will be noted

(toward the right in FIG. 44) that where the rock floor is slightly inclined the layer of peat becomes thinner. Swamp *C* differs from both swamps *A* and *B* in having originated in and around a shallow, poorly drained pond, the extreme depth of which was not ascertained. In its larger aspects, the vegetation in both these swamps is similar to that of swamp *A:* the two species of *Scirpus* and the *Sphagna* predominate, and various species characteristic of both well-drained and undrained swamps are represented. But the still more boggy nature of the habitat is evidenced particularly by the frequency here of the ericaceous shrubs, *Chamaedaphne calyculata* and *Ledum groenlandicum,* neither of which occur in swamp *A*. The relatively xerophytic nature of the habitat is further suggested by the presence of *Pteris aquilina* and *Juniperus communis depressa.*

The following list of species characteristic of one or all of the Broadcove Mountain swamps, but mostly not heretofore mentioned in any connection, is of interest.

Selaginella selaginoides
Larix laricina
Muhlenbergia racemosa
Eriophorum tenellum
Eriophorum viride-carinatum
Carex Michauxiana
Carex oligosperma
Spiranthes Romanzoffiana
Potentilla fruticosa
Viola conspersa
Conioselinum chinense
Solidago rugosa
Solidago uliginosa
Cirsium muticum

General observations.—In general, bogginess seems to be correlated with poor drainage; and this may be either occasioned by the nature of the terrain or brought about through the influence of vegetation. Topography favors the development of boggy swamps where the surface is flat, fairly level, and so situated that the ground becomes covered with a thin sheet of water in wet weather. Boggy swamps are frequently encountered, for example, on low, flat areas, bordering lakes and ponds, which are subject to periodic inundation (see in this connection p. 419). A heavy soil which dries out slowly favors the development of boggy swamps. But many of the tracts, which in northern Cape Breton are occupied by swamps of this type, in a warmer, less humid climate would be merely periodic swamps of the ordinary, well-drained type. The general prevalence here

of boggy swamps may be attributed in large measure, indirectly, to the influence of the cool, humid climate of the region. The climate favors the luxuriant development of the sphagnums and other peat-forming plants, and it seems to be very largely through the direct influence of the layer of peat to which these give rise, in retaining the water and thereby extending the swampy condition throughout the season, that the boggy condition is brought about. Very often, in this way, through the obstruction of the drainage which results from the activity of the vegetation, a swamp which, during the early stages of its development, would be classed as well-drained, in the course of time becomes increasingly boggy. This is well illustrated by the examples just described.

It has been mentioned earlier that peat accumulation may occur in connection with well-drained swamps; but there, as already suggested, the deposit is mucky and invariably shallow. Again, the bog has been cited as the characteristic swamp-type of undrained depressions; but not infrequently shallow, undrained depressions are occupied by swamps of the poorly drained type. Sink hole swamps are often of this character. Fluctuations in water level, underground drainage, alkalinity of the soil water, or some such factors may perhaps explain the discrepancy here. But, after all, the whole swamp situation is an extremely complex one, and it is candidly admitted that there are any number of questions which must be left unanswered.

4. The formation-types in and along Rivers and Streams

a. INTRODUCTORY

Under this head are included fundamentally those association-complexes of hydrarch origin whose ecological aspect manifestly is correlated with the activity of rivers and streams. In so far as it affects associations of the hydrarch series, the influence of a stream on the vegetation in and along its course is expressed primarily at times of high water, and then in two ways: first, through the deposition of sediment, which leads to the development of flood plains; second, through the erosive activity of the current, which may affect the vegetation directly, particularly through the abrading action of ice, or indirectly, as seen in the formation of oxbows. Under this head have also been included

the association-complexes of wet or dripping rock outcrops, since these are especially characteristic of, though by no means confined to, ravines.

b. THE ASSOCIATION-COMPLEXES OF RAVINES

The stream bed association-types.—The predominant plants in the rocky stream beds which prevail in ravines, and to a large extent elsewhere, are bryophytes. Characteristic species are the following:

Marsupella aquatica
Jungermannia cordifolia
Scapania undulata
Porella pinnata
Fontinalis dalecarlica
Oxyrrhynchium rusciforme
Hygrohypnum dilatatum
Hygrophynum eugyrium
Hygrophynum ochraceum

The degree of luxuriance exhibited by the submersed bryophytic vegetation varies greatly in different streams. The aquatic mosses and liverworts are best developed in small brooks; in large streams they may be conspicuous by their absence. This latter fact may be explained somewhat as follows. The instability of the substratum might account for their absence on small boulders and cobbles, but even where there is a firm rock substratum, bryophytes are scarce. There seems little question that, in general, the scarcity is attributable to mechanical factors —to the erosive action of the sediment-laden water in flood time, or, more likely, of ice-laden water in spring. Were the phenomenon restricted to northern Cape Breton, one might feel tempted to correlate it with the acidity of the water, which in most streams commonly contains so much organic matter that it is colored yellow or brownish (see, in this connection, Ganong '98); but the same conditions can be observed in other regions, e. g., in Connecticut streams, where the water is clear and colorless. Often the rocky bottom in swift streams is utterly devoid of plants of any description, but sometimes, in the absence of mosses, there may be a considerable growth of *Nitella* sp.

Stream bank association-types.—Along small ravine brooks the banks, as a rule, are well shaded by overhanging foliage, the air is always cool and moist, and the substratum continuously damp or wet. It is doubtful whether the plant cover

in many such habitats ever has been xerophytic, and for this reason it has seemed best to treat it under the head of hydrarch successions. The outstanding feature of such a ravine is the intense mesophytism, commonly verging on hydrophytism, of its vegetation. In the periodically inundated zone along the edge of the stream there is a profuse development of mosses and liverworts, which commonly include, among others, the following species:

Conocephalum conicum
Plagiochila asplenioides
Sphagnum squarrosum
Fissidens adiantoides
Mnium hornum
Mnium punctatum
Philonotis fontana
Thuidium delicatulum
Brachythecium rivulare
Hylocomium brevirostre
Climacium dendroides
Catharinaea undulata

Vascular plants are more or less numerous, particularly toward the upper limit of the flood zone. Here the ferns are represented by a wealth of species, among which *Polystichum Braunii* is especially characteristic, while the seed plants include some of the most pronounced shade- and moisture-loving mesophytes. A list of some of the more representative ferns and seed plants follows:

Phegopteris polypodioides
Phegopteris Dryopteris
Asplenium Filix-femina
Polystichum acrostichoides
Polystichum Braunii
Aspidium noveboracense
Aspidium spinulosum var.
Streptopus amplexifolius
Geum macrophyllum
Circaea alpina
Galium kamtschaticum
Aster acuminatus

Along the larger ravine streams the banks are more exposed to sun and wind than along the smaller ones, and the vegetation tends to be less mesophytic, with shade plants in particular much less prominent. The character of the vegetation between low and high water levels is influenced to a more marked degree by the abrading action of the current in flood time. Even here, however, associations of the sort just described are frequently encountered.

Cliff association-types.—Many cliffs and steep rock outcrops are kept wet to such a degree with dripping water that their

vegetation differs quite perceptibly from that of the drier cliffs described earlier under the xerarch series. It is of course difficult to draw sharp lines, since there are all degrees of intergradation. Here, as there, the most distinctive plants are the bryophytes, which thrive in crevices and frequently plaster over even precipitous rock surfaces. But in addition to various of the species cited earlier as characteristic of relatively dry cliffs, there occur here, usually as the predominant forms, various more or less hydrophytic species. Prominent among these are the sphagnums, the species mainly those mentioned elsewhere in connection with the ravine forest, and the liverworts and mosses enumerated in the subjoined list.

Marsupella emarginata
Sphenolobus Michauxii
Mylia Taylori
Plagiochila asplenioides
Diplophyllum albicans
Scapania nemorosa
Blindia acuta
Didymodon rubellus
Hymenostylium curvirostre
Anoectangium Mougeotii
Plagiothecium denticulatum
Hylocomium brevirostre
Plagiopus Oederi

c. THE ASSOCIATION-COMPLEXES OF FLOOD PLAINS

Here should be included the strips of swale which not infrequently border even rapid streams and which obviously represent incipient flood plains. In valleys, for example, and locally even in ravines, a narrow, marshy strip frequently intervenes between ordinary summer water level and the lower edge of the upland forest. The vegetation in such a tract is essentially that of a well-drained swamp, with sedges, such species as *Carex torta* and *C. aquatilis,* and the grass, *Calamagrostis canadensis,* usually the predominant forms. Swampy flood plains of this particular sort are much more extensively developed on the plateau (see p. 456) than in the lowland, where they are of minor consequence.

Of much more importance here, though somewhat restricted in their occurrence, are the flood plain formations which have been developed in particular at the mouths of some of the larger streams, as at the heads of Ingonish Harbor, Middle Harbor (Aspy Bay), and Margaree Harbor. The earlier phases of the hydrarch series of association-types, which reaches its culmina-

tion in the flood plain forests that have been developed on the higher portions of flood plains, are well illustrated by the conditions about the head of Margaree Harbor, which will be briefly described.

Pioneer association-types.—Owing to the intermittent backing up of the outflowing river water by the inflowing tide water, the depth of the water over the submerged portion of the flood plain here fluctuates daily. On parts which are permanently submerged, vegetation, where present, consists largely of submersed aquatics, notably *Potamogeton bupleuroides.* Areas which are bared at low tide, but which may be inundated to a depth of from perhaps six inches to two feet at high tide, are occupied by a wet marsh association-type, in which the following are the more prominent species:

Equisetum fluviatile
Scirpus occidentalis
Dulichium arundinaceum
Typha latifolia
Sagittaria latifolia
Acorus Calamus
Castalia odorata
Nymphaea advena
Cicuta bulbifera
Sium cicutaefolium

Fringing the shoreward margin of this marshy area is a more or less well defined transition zone, in which the predominant plants are species of generally recognized amphibious proclivities. Here, to a greater extent than in the areas of deeper water, grow, among others, the following species:

Leersia oryzoides
Juncus brevicaudatus
Iris versicolor
Caltha palustris
Rumex Britannica
Potentilla palustris
Proserpinaca palustris
Lysimachia terrestris
Menyanthes trifoliolata
Myosotis laxa
Mentha arvensis

On portions of the flood plain where the water at high tide ordinarily is very shallow, or which are flooded only in time of spring tides, the general aspect of the association-type is that of wet meadow, although various of the marsh species may grow here also. Below is a list of some of the species noted as characteristic:

Acrocladium cuspidatum
Onoclea sensibilis
Aspidium Thelypteris
Glyceria grandis
Calamagrostis canadensis
Carex crinita
Habenaria dilatata
Sanguisorba canadensis
Impatiens fulva
Viola cucullata
Scutellaria galericulata
Chelone glabra
Eupatorium purpureum
Aster novi-belgii

The edaphic climax association-type.—The condition of the vegetation on parts of flood plains which lie above ordinary high tide level has been greatly modified by human activity, owing to the suitability of such areas for raising hay, and the original character of the vegetation here must be judged from the fragmentary evidence which has survived.

In wet meadows of the sort above described, the common occurrence of scattered shrubs, such as *Alnus incana* and *Myrica Gale,* suggests that the present day meadow association-type is of secondary origin; and it is certain, from the conditions observed at Margaree Harbor, Ingonish, and Aspy Bay, that in former days the higher parts of flood-plains of the sort under consideration were occupied by forests made up largely of elm, white ash, black ash, and white spruce. Specimens of elm more than six feet in diameter are occasionally encountered on flood plains. The characteristic shrubs here include *Salix* sp., *Alnus incana, Cornus stolonifera, Viburnum Opulus americanum,* and *Sambucus canadensis.* Below is a list of the more distinctive herbaceous species of the higher parts of flood plains, most of them being noted in all three localities cited.

Onoclea Struthiopteris
Onoclea sensibilis
Asplenium Filix-femina
Calamagrostis canadensis
Laportea canadensis
Thalictrum polygamum
Clematis virginiana
Agrimonia striata
Sanguisorba canadensis
Impatiens biflora
Circaea intermedia
Heracleum lanatum
Galium asprellum
Eupatorium purpureum
Solidago canadensis
Solidago rugosa
Aster novi-belgii
Aster puniceus
Aster umbellatus

The association-types of oxbow ponds.—Oxbow ponds have been observed in a few places, as at Margaree Harbor and Pleasant Bay. Such ponds usually support a luxuriant aquatic vegetation, notably such species as the following:

Sparganium angustifolium
Potamogeton bupleuroides
Potamogeton epihydrus
Scirpus subterminalis
Nymphaea advena
Nymphaea microphylla
Castalia odorata
Ranunculus aquatilis capillaceus
Callitriche palustris
Ludvigia palustris
Myriophyllum verticillatum
Utricularia intermedia
Utricularia vulgaris

The marginal vegetation here requires no particular comment. It may include any of the wet marsh species of the flood plain series, in addition to various of the herbaceous plants and shrubs elsewhere listed as characteristic of well-drained swamps.

4. The Formation-types along the Seacoast

a. INTRODUCTORY

In this group may be included all association-complexes of hydrarch origin whose ecological aspect is influenced directly by the proximity of the sea. This influence is seen most obviously in the effect of salt water on the character of the vegetation. But beside this, from the standpoint of physiographic ecology, the dynamic agencies which are associated with the activity of waves and currents are of prime importance, either directly or indirectly: the formation and destruction of barrier beaches, which may result in the development of coastal ponds of all degrees of salinity—from completely salt to completely fresh; the deposition of sediment, which under favorable conditions may lead to the development of coastal swamps, etc. With reference to these physiographic agencies, just as was pointed out in discussing the vegetation of uplands along the seacoast, it is possible to divide the associations of lakes and swamps here into two groups: associations along eroding shores, and associations along depositing shores. Little attention has been given, however, to the associations of the first group, which comprise primarily the formation (or formation-complex) of seaweeds

concerning which brief mention has already been made in discussing the vegetation of rocky sea bluffs. In the remarks which follow, attention is restricted to the associations along depositing shores. These are conveniently treated under three heads: the association-complexes of salt and brackish lakes and ponds, the association-complexes of salt marshes, and the association-complexes of brackish marshes.

b. THE ASSOCIATION-COMPLEXES OF SALT AND BRACKISH LAKES AND PONDS

The most prominent constituent of the aquatic flora in salt lakes and ponds is the eel grass (*Zostera marina*) which commonly grows in great luxuriance, covering large areas of bottom between approximately mean low water mark and a depth of several feet below. Ecologically the eel grass fulfils an important function in that, by its interference with tidal currents, it stimulates the deposition of silt and the consequent upbuilding of the bottom. Associated with the eel grass, but seldom attaining any great prominence, usually grow the sea lettuce (*Ulva* sp.) and other algae, which may either form a loose covering over the sandy or muddy bottom or grow attached to the eel grass. Another seed plant found here is *Ruppia maritima*. In Middle Harbor (Aspy Bay), to select a concrete example, this plant is not at all conspicuous toward the outlet, but in the shallow water about the head of the harbor, in company with *Potamogeton pectinatus*, it completely covers the muddy bottom with a prolific growth. The presence here at the head of a sizeable stream may account for the abundance of the *Ruppia* in this vicinity, although this plant is by no means confined to brackish water. In Cold Spring Harbor, Johnson ('15, p. 26) says that *Ruppia* is most abundant in areas of "soft bottom, bare of *Ulva*, and usually protected from currents and waves." It is worthy of note, however, that in brackish ponds, in northern Cape Breton, the bulk of the aquatic vegetation consists of *Ruppia* and *Potamogeton pectinatus*.

The shores of salt and brackish ponds may be occupied by the salt or brackish marshes which will be described presently, or they may be merely muddy or gravelly. Gravelly shores ordinarily occur in more exposed situations than muddy shores. The conditions which prevail on gravelly shores may be illustrated

by a specific example, a spot just inside the entrance of a salt pond. A luxuriant growth of *Plantago decipiens, Spergularia leiosperma,* and *Salicornia europaea* covers much of the shore between mean high and low water levels. Attached to scattered cobbles in this zone are *Fucus, Ascophyllum,* and other algae. In the vicinity of high water mark grow *Puccinellia maritima, Suaeda maritima, Solidago sempervirens* and other halophytes. Such a shore may be regarded as an incipient marsh.

The vegetation of muddy shores is essentially that of the marshes. The conditions here are well exemplified by a small brackish pond near the Barrasois, which has become completely barricaded off from the ocean but is still influenced by tide water filtering through the barrier. The pond itself is densely populated by *Ruppia* and *Potamogeton pectinatus,* together with various algae. Surrounding the pond is a low, muddy border from two to five feet wide, which is ordinarily submerged at high tide. The predominant plant here is *Scirpus nanus,* which forms a low, soft sward. Associated with it grow *Triglochin maritima, Ranunculus Cymbalaria, Spergularia canadensis,* and *Salicornia.* At a slightly higher level, barely covered at ordinary high water, is a narrow zone of *Spartina patens,* together with *Agrostis alba maritima, Carex norvegica,* and *Triglochin;* while at a still higher level, not submerged by ordinary tides, is a zone occupied almost exclusively by *Juncus balticus littoralis.* Such an association-complex, like the preceding, might equally well, if not better, be considered in connection with salt and brackish marshes.

c. THE ASSOCIATION-COMPLEXES OF SALT MARSHES

As might be anticipated, in view of its exposed coastline, coastal swamps are nowhere extensively developed in northern Cape Breton. The finest area of this sort which has come to the writer's attention is situated along the oceanward shore of South Pond (Aspy Bay), bordering the pondward side of the sand-spit elsewhere described, and extending out into the salt pond nearly a quarter of a mile (Fig. 45). This particular salt marsh is of unique interest because of the presence here *in situ* of a number of large white pine stumps. These occur scattered throughout the landward half of the marsh and their roots are

well exposed above its surface. The explanation for this unusual condition seems to be this. The pines formerly grew on a low, sandy, pondward extension of the present spit. Through some shifting in the tidal currents the sand was eroded away from around the bases of the trees, and subsequently, presumably as the result of further shifting in the current, deposition has succeeded erosion and the salt marsh has been built up. The active erosion of the sand spit which is now taking place along

FIGURE 45.—Salt marsh at South Pond, Aspy Bay; scattered stumps in marsh; see text.

certain other sections of the shore upholds the plausibility of the explanation just given, and excavation of the muddy deposit about the stumps shows beach-sand at a depth of scarcely a foot below mean low tide level (in this connection, see also Harvey '18).

The pioneer association-type.—The mechanics of salt marsh formation need not be detailed here: suffice it to say that it is accomplished through the combined activity of plants and physiographic agencies (see in this connection, Davis '10). In northern Cape Breton, as in salt marshes along the New England coast, the pioneer stage in the salt marsh successional series is

dominated by the rank-smelling salt thatch (*Spartina glabra alterniflora*). In typical cases this grass forms a fringe along the outer edge of the marsh. It predominates from about a foot above mean low tide level upward to within a few inches of mean high water mark, its actual vertical range being scarcely two feet. Except for *Vaucheria* and certain other filamentous algae, which commonly thrive on the muddy substratum, the salt thatch is ordinarily the only plant present in this outermost zone (*Spartina glabra* association-type).

The salt meadow association-types.—By the time the surface of a marsh has been built up to such a height that it is submerged for only a few hours daily, the pioneer association-type has given way to salt meadow: the rank, but open growth of tall, coarse salt-thatch has become superseded by a sward of lower, finer grasses, predominantly the salt meadow grass (*Spartina patens*). Along with the salt meadow grass in this association (*Spartina patens* association-type) commonly grow in greater or less abundance: *Distichlis spicata, Triglochin maritima, Plantago decipiens,* and *Limonium carolinianum.*

At this point there is one feature which is almost universally associated with salt marsh building and which demands a few words of comment. During the elevation of the substratum there may arise in various ways, which will not be discussed in detail here (but see in this connection, Yapp and Johns '17; Johnson and York '15, pp. 22, 25, etc.; Harshberger '16), sloughs and depressions which become generally distributed throughout the higher parts of the marsh. Here the depressions may be deep or shallow; they may be filled much of the time with more or less stagnant water or may be merely muddy. In the majority of these so-called "pans" the difference in level between their bottoms and the higher surfaces of the surrounding meadow is but a matter of inches or even fractions of an inch, yet they present an environment for plants which is quite different from that afforded by the higher, better drained areas. The pans may be quite barren of vegetation or they may be well populated, but their plant cover is usually in marked contrast with that of the surrounding meadow. Especially characteristic of such situations are *Salicornia europaea* and *Spergularia canadensis,* which, one or both, may be the only forms present or which may grow in association with such species as *Scirpus*

nanus, Glaux maritima obtusifolia and *Puccinellia maritima.* Again, the pans may be colonized almost exclusively by the salt thatch, which in such situations forms a dense but usually depauperate growth, while *Distichlis* frequently skirts the edges.

In proceeding from the outer margin of a salt marsh toward the mainland, the general level of the surface becomes slightly higher and the general character of the vegetation changes correspondingly. But even in the older, higher parts, owing to the local variations in elevation and drainage, the surface vegetation is far from being uniform. The predominant plant on the higher, shoreward reaches of the salt meadow is *Juncus balticus littoralis* (*Juncus balticus* association-type), which in the salt marshes of northern Cape Breton occupies an ecological position quite similar to that held by *Juncus Gerardi* in regions farther south. The latter species is seldom met with here. Associated with the *Juncus,* and locally dominant, may be *Agrostis alba maritima, Hierochloë odorata, Scirpus campestris paludosus,* and *Eleocharis palustris.* The two latter species are especially well developed in the wetter situations, where also *Ranunculus Cymbalaria* and *Potentilla pacifica* are commonly present. Other species characteristic of the shoreward reaches of the salt meadows are *Triglochin palustris, Stellaria humifusa, Atriplex patula hastata, Solidago sempervirens,* and *Aster novi-belgii.* In addition to these, the salt thatch and most of the species of the *Spartina patens* association-type are represented here: *Spartina glabra, Scirpus nanus, Spergularia,* and *Salicornia* in poorly drained depressions; *Spartina patens* and *Plantago decipiens* in low but fairly well-drained situations. *Limonium,* however, apparently is confined to the outermost meadows.

c. THE ASSOCIATION-COMPLEXES OF BRACKISH MARSHES

Brackish marshes are of far more general occurrence than salt marshes. To some extent they are developed toward the mouths of many of the larger streams (Fig. 46), but the finest examples observed are situated at the heads of Ingonish Harbor and of Middle Harbor (Aspy Bay). The vegetation of brackish marshes includes many of the plants which have been listed as characteristic of salt marshes, but it also includes other species which are rarely represented there. The wetter parts of a

brackish marsh ordinarily support a rank growth of coarse sedges, notably *Scirpus occidentalis, S. campestris paludosus, Carex maritima,* and *C. salina.* These, singly or collectively, may constitute the pioneer association-type. On the higher parts of the marsh the predominant forms usually are *Juncus balticus littoralis* and *Agrostis alba maritima.* Other forms which may be more or less abundantly represented in brackish marshes are listed below.

FIGURE 46.—Brackish marsh near mouth of Barrasois.

Triglochin maritima
Triglochin palustris
Hierochloë odorata
Spartina Michauxiana
Eleocharis palustris
Scirpus americanus
Scirpus rufus
Eleocharis palustris
Carex Oederi pumila
Juncus pelocarpus
Atriplex patula hastata
Spergularia canadensis
Potentilla pacifica
Plantago decipiens
Solidago sempervirens
Aster novi-belgii

Transitions from salt to brackish, from brackish to fresh swamps, etc.—It is impossible to draw a sharp line between

brackish and salt swamps, on the one hand, and between brackish and fresh swamps, on the other. In the character of the predominant plants, the vegetation of the higher, shoreward reaches of a well developed salt marsh almost invariably resembles that of a brackish meadow, and it commonly includes various species characteristic of fresh water swamps. Along the shoreward edge of a salt marsh, for example, in places where unquestionably they are subject to partial submergence in salt water, at least by the high, semi-monthly "spring-tides," commonly grow such non-halophytic swamp species as *Iris versicolor, Sanguisorba canadensis,* and *Lysimachia terrestris; Vaccinium macrocarpon, Alnus incana, Myrica Gale,* and *Spiraea latifolia.* By way of further illustration, two specific transitional series will be briefly described.

MacDonald's Pond, near the mouth of the Barrasois, affords an unusually interesting illustration of this sort. At the present time the pond, which is perhaps half a mile long, is completely shut in by a barrier beach and its water is brackish; but within twelve years it communicated with the sea by a narrow outlet. Around much of the margin the vegetation is similar to that described in preceding paragraphs. The area of particular interest is a sheltered cove, connected with the main pond by a shallow open channel a dozen feet wide, presumably fed by springs, and occasionally (probably every spring) the recipient of the flood waters of the Barrasois, which reach it through a channel ordinarily dry. This cove has been for the most part filled in to a depth of more than a dozen feet with a mixture of peat and silt. From a small but deep pool near the center of the swamp thus formed to the outlet of the cove runs the open channel already referred to. Toward the outlet of the swamp, the vegetation is predominantly that of a slightly brackish marsh, consisting largely of *Spartina Michauxiana, Agrostis alba maritima, Scirpus americanus,* and *Eleocharis palustris,* together with *Potentilla pacifica, Triglochin palustris,* and *Carex maritima.* In the open water of the channel grow *Ruppia maritima* and *Potamogeton pectinatus.* Bordering the pool is a zone of *Typha latifolia,* followed by a zone of *Juncus balticus littoralis.* But throughout the remainder of the area the vegetation is predominantly that of a fresh swamp, the more prominent herbs including *Calamagrostis canadensis, Scirpus cyperinus, S.*

rubrotinctus, Carex canescens disjuncta, C. crinita, C. paupercula irrigua, Juncus filiformis, Sium cicutaefolium and *Galium palustre*. Considerable patches have been preëmpted by *Myrica Gale,* while *Sphagnum imbricatum* is locally abundant. From a superficial study it would appear that at the present time the fresh swamp, presumably as a result of the comparatively recent complete cutting off of MacDonald Pond from the sea and the consequently decreased salinity of the water, is gradually encroaching on a former brackish marsh whose vegetation over most of the swamp is now represented only by scattered relicts. But, as a matter of fact, the situation is much more complicated. This is merely suggested here, without attempt at explanation, by the facts (*1*) that while there are no living trees in the swamp there are numerous dead spruces, and (*2*) that a sample of the peat taken near the margin of the central pond showed abundant sphagnum remains at a depth of twelve feet below the surface.

Another interesting transitional series, in this case from salt pond to boggy swamp, was observed along the shores of North Pond, Aspy Bay. Here, starting from low water mark and proceeding inland, within a distance horizontally of scarcely a hundred feet one passes through the following associations: (*a*) *Sparitina glabra alterniflora* and *Spergularia canadensis;* (*b*) *Spartina patens;* (*c*) *Juncus balticus littoralis, Agrostis alba maritima,* and *Ranunculus Cymbalaria;* (*d*) *Scirpus occidentalis;* (*e*) various species of *Carex, Alnus incana, Myrica Gale, Vaccinium macrocarpon, Chrysophynum stellatum,* etc.; (*f*) boggy swamp with *Carex trisperma, Rynchospora alba, Sarracenia, Drosera rotundifolia, Vaccinium Oxycoccus, Chamaedaphne, Ledum,* various *Sphagna,* etc. Area *a-e* are below mean high tide level, area *d* is partly above and partly below, area *e* is barely out of reach of ordinary high tides, and area *f* extends down to within less than a foot (vertically) of mean high water mark.

In discussing the occurrence along the shore of Cold Spring Harbor of non-halophytic vascular plants, in places where the soil is often covered by salt water, sometimes for as much as three or four hours daily, Johnson ('15, p. 110, etc) explains the situation somewhat as follows. The ground in such places is usually springy, and the soil is saturated with fresh water, the

abundance of which "prevents the salt water from really penetrating it." In such situations, therefore, many upland and fresh swamp plants which can stand more or less inundation of their shoots with salt water but which cannot endure salt water around their roots are enabled to push down to much lower levels than usual, even growing below mean high tide level. This explanation is doubtless the correct one, and the line of demarcation between halophytic and non-halophytic associations is always sharper along dry than along wet shores, although even here non-halophytic plants frequently invade areas which are subject to tidal overflow.

Of peculiar interest in this connection is the occurrence of bryophytes in situations where they must necessarily be more or less exposed to the influence of salt water. In northern Cape Breton, for example, *Chrysohypnum stellatum* commonly grows quite abundantly on the wet soil of brackish meadows, in company with such vascular species as *Triglochin palustris* and *Ranunculus Cymbalaria*, and the sphagnums sometimes occur in similar situations. *Sphagnum palustre* and *Bryum inclinatum* have been collected on exposed sea cliffs well within reach of storm waves, while *Bryum fallax* thrives around the edges of salt ponds. From these and similar observations elsewhere, there seems little question that while as a class the bryophytes may be regarded as halophobous, many of them are capable of existence in habitats where, periodically at any rate, they are bathed in brackish or salt water.

D. Secondary Formations of the Hydrarch Series

Formation-types resulting primarily from Human Activity

Association-complexes due to various agencies

In so far as the association-types of lakes and ponds are concerned, the effect of human activity has been negligible. The vegetation of swamps has been variously modified, but it is only occasionally that it has suffered as severely as that of uplands. This state of affairs, in the main, is easily explained by the fact that in this climate, with its abundant atmospheric precipitation, the swamps, for the most part, are of comparatively little value from the cultural standpoint. Instances of a more or less pronounced change in swamp vegetation from its original character

are afforded by well-drained swampy areas which have been converted into meadow-land. Here sedges and grasses predominate and the vegetation approximates more or less closely that elsewhere described as characteristic of open, well-drained swamps. Grazing cattle and sheep may bring about the introduction into a swampy area of plants not previously present and they may appreciably retard succession, but otherwise they do not seriously modify the conditions. Aside from instances such as those just outlined, any changes in the vegetation and succession in the swamps which are attributable to human activity have been largely due to logging and fire. The former agency may have resulted in the removal of the original forest cover, where one was present, but beyond this has had little retrogressive effect on the vegetation in the areas concerned. The influence of fire is much less in swamps than on uplands, since the very wetness of the substratum may prevent the complete destruction of subterranean plant organs. In general, the association-types of secondary hydrarch series appear to differ little from those of the primary series as described elsewhere.

THE NORTHEASTERN EVERGREEN CONIFEROUS FOREST CLIMATIC FORMATION IN NORTHERN CAPE BRETON

I. GENERAL CONSIDERATIONS

Distribution and general character.—By far the greater part of northern Cape Breton, indeed nearly all the country above an elevation of approximately seven hundred feet, is occupied by this formation. With reference to the general ecological aspect of the vegetation, however, the area thus defined can be subdivided into two regions: (*1*) the forest region proper, which hereafter will be referred to simply as the Forested Region; and (*2*) the Barrens. The extent of these regions is roughly indicated on the map (Fig. 2). In a general way, the forested region can be said to include the upper mountain slopes, together with the outer and lower, less exposed parts of the plateau. Here the country is covered by an almost unbroken forest of balsam fir, spruce, and paper birch (Figs. 4, 47, 49). The barrens (Figs. 48, 51, etc.) include primarily the higher, more exposed portions of the plateau, being especially well developed toward the interior, and occupying altogether an area estimated by Fernow ('12, p. 20) at about 375 square miles. Here forests of the usual description are largely confined to the "gulches," while the country at large is covered mainly by heath and scrubby forests, swamps and bogs ("muskeag").

Evergreen coniferous forest in the highlands a climatic, not an edaphic climax.—In a brief summary report of field work in Cape Breton, Macoun ('98, p. 199A), records the following observations: "Before going to Cape Breton, I had, like many others, a very mistaken notion of the 'barrens'[12] in the northern part of the island. After spending some time in the north and on the plateau, the conditions producing these barrens became evident. Along the base of the escarpment bordering the plateau, the subsoil is generally impervious, and here spruce and fir occupy the ground. The broken face of the escarpment is

[12] Macoun here seems to use this term in a much more comprehensive sense than that in which it is employed by the writer.

usually covered with broad-leaved trees, such as maple, beech and birch, because it is well drained." In other words, Macoun would seem to intimate that in the mountains, as the writer has shown to be locally the case in the lowland, the evergreen coniferous forest is to be regarded as an edaphic rather than

FIGURE 47.—Primeval coniferous forest of the regional climax type; mountains near Cape North.

a climatic climax association-type. With this opinion the writer emphatically disagrees for reasons which are briefly outlined below.

In ascending the mountain slopes which flank the plateau, there is a gradual transition from the forests of the lowland climax type to those of the highland, a transition which has been repeatedly traced out and verified. In passing upward, the

character trees of the deciduous climax formation disappear in approximately the following order: beech; hemlock; oak and sugar maple; white pine; red maple; yellow birch. Except for the two species last named, none of these are represented in the evergreen coniferous climax forests of the highland. The yellow birch, however, is frequently encountered here in edaphically favorable situations, while the red maple is commonly represented by shrubby specimens, which, however, seldom attain the dignity of trees. It is also significant that for some distance above the level where it ceases to occupy a prominent position in the forest, the sugar maple still maintains an important place in the undergrowth, being represented here by more or less abundant, scraggly, shrubby specimens, which exhibit unmistakable evidence of having been repeatedly killed back. It is further significant that there is a marked correlation between the vertical distribution of most of these trees in northern Cape Breton and their north-and-south geographic range; and it is of interest to observe that toward its upper limits the deciduous-mixed forest commonly is dominated by the yellow birch.

The facts just presented, and particularly the complete absence on the plateau, even in the many situations which are edaphically favorable, of beech, sugar maple and oak, hemlock and white pine, would seem to indicate conclusively that the factors responsible for the character of the climax association-type here are climatic and not edaphic. The controlling factor in determining the upward extension of the deciduous forest climatic formation is probably temperature (see discussion elsewhere under head of climate). But atmospheric humidity may also be a decisive factor, since the upper limit of the deciduous climax forest coincides approximately with the lower limit of the low-lying cloud belt in dull weather, a feature which has been commented on earlier (p. 274).

The status of the barrens, from the standpoint of ecological plant geography.—The barrens are of peculiar interest, since they present essentially the same type of vegetation that prevails over vast areas on the Labrador Peninsula and throughout northern Canada, regions concerning which almost nothing is known ecologically. So distinct in its general aspect from that of the forest region proper is the vegetation of the barrens that it was at first thought to constitute a distinct climatic formation.

Further investigations, however, have indicated beyond question that this remarkable formation-complex, in northern Cape Breton, is the result of edaphic rather than climatic factors. The climax association-type of uplands in the barrens bears much the same relation to the coniferous forest climax of the highlands that the climax association-type of exposed headlands along the seacoast bears to the deciduous forest climax of the lowland. The relation between the edaphic formation-complex here and

FIGURE 48.—Barrens in mountains north of Barrasois River (Scotchman's Barren); vegetation closely approximating heath; tamaracks in left foreground and mid-distance.

that of the highlands as a whole is somewhat analogous to the relation between the edaphic formation-complex of the New Jersey pine barrens and that of the whole state of New Jersey. The character of the vegetation in the barrens is attributable very largely, directly or indirectly, to conditions of exposure, topography, and soil. Along the streams the climax forests of the forested area extend into the heart of the barrens, while, conversely, in high, exposed situations the vegetation of the barrens reaches well toward the coast.

Forest resources of the region.—In summing up the results of a timber survey of this region, made a number of years ago,

Fernow ('12, pp. 20, 24) estimated the commercially productive forest area of the "1200 square miles of plateau" at about 780 square miles, the unproductive area being largely occupied by barrens. He describes the forest as "an almost unbroken pure balsam fir forest, with only 15 per cent. to 25 per cent. of spruce, except in the black spruce swamps, and about three per cent. of birch," in which "the trees run from 6 to 14 inches in diameter, occasionally up to 18 inches, with 36 feet log length, and ten trees to the cord." Among the sample plots measured in connection with this survey, some 180 in all, many ran from fifty to sixty cords per acre, with an average of at least twenty. The forest is of value chiefly for pulpwood; saw timber is scarce. On a basis of the figures obtained, Fernow estimates that the area contains twelve million cords of pulpwood, or an amount equal to that which is computed to be present in the entire province of Nova Scotia outside of northern Cape Breton, an area more than sixteen times as large. And while these facts are primarily of economic import, they are also of ecological interest, since they serve to emphasize the dissimilarity between the forests of this region and those in other parts of Nova Scotia.

Apropos, it may well be suggested here that while, as has been shown in preceding pages, conditions over much of the lowland are favorable to the development of forests of the deciduous climax type, they are even more so to the growth of coniferous forests. It is only through their inability, in the long run and under natural conditions, to cope successfully with their southern competitors that the northern conifers do not today constitute the predominating element in the primeval, as well as in the second growth forests of this region. Both climate and soil are more favorable here than in the highland. It is the conviction of the writer that the commercial production of spruce and balsam fir in the lowland of northern Cape Breton offers large possibilities for the future.

II. THE REGIONAL CLIMAX ASSOCIATION-TYPE: THE CLIMAX FOREST

The trees of the climax forest.—The general aspect of these forests is well portrayed by Figs. 47, 49. The balsam fir is by far the most abundant species, comprising ordinarily more than

75 per cent. and sometimes fully 85 per cent. of the stand. Individual trees may attain a trunk diameter in excess of sixteen inches with a height approaching seventy feet, but such specimens are exceptional: the bulk of the balsams which go to make up the mature forest run from eight to twelve inches in

FIGURE 49.—Primeval coniferous forest of the regional climax type; mainly balsam fir; mountains north of Barrasois River.

diameter, mostly about ten, and range around fifty feet in height. The average age of such trees, as ascertained in many cases with the aid of an increment borer, would scarcely exceed seventy years. Occasional specimens are encountered which must be 125 or more years of age, but the exact age of these larger specimens it is seldom possible to determine accurately, owing

to the fact that almost invariably they are heart rotted. It is a noteworthy fact, as Cooper ('13, pp. 17–21) has pointed out, that while the balsam fir far outnumbers all other trees in the forest, yet, owing to its susceptibility to fungus attack and consequent liability to windfall, its relative abundance decreases greatly with age. In other words, "its high birth-rate is balanced by a high rate of mortality."

Second in importance to the balsam fir in the climax forest is the white spruce, which is well distributed throughout, common, yet nowhere approaching the balsam in abundance, and conspicuous by reason of its relatively large size. It ordinarily attains a diameter of sixteen inches, sometimes of more than two feet, and as a rule is correspondingly taller than the balsam. Black spruce is also an important constituent, locally quite common, and in size about equal to the balsam. It never attains here the proportions which it exhibits in the Adirondacks where, in virgin forests, trees three feet in diameter and more than a hundred feet high are frequent. These three trees comprise the evergreen coniferous element in the climax forest. The deciduous element is represented primarily by two species, the paper birch and the mountain ash. The paper birch is well scattered through the forest, somewhat less abundant, perhaps, than the white spruce, but prominent by reason of its showy bark and spreading, broad-leaved crown. In height it seldom exceeds the average for the forest as a whole, and its trunk is rarely as much as a foot in diameter. The mountain ash is a very characteristic and omnipresent constituent, usually a small undertree, but sometimes fully fifty feet high with a trunk a foot in diameter. The yellow birch, though frequently represented in favorable situations, never reaches anywhere near the size which it attains in the lowland. Red maple is more or less scattered throughout, but as a rule is little more than an undershrub. The small-toothed aspen (*Populus tremuloides*) also is occasionally present.

The undergrowth in the climax forest.—Below is given a list of the characteristic shrubs and herbaceous vascular plants in the coniferous climax forest. Their general occurrence and local abundance when present is indicated by symbols, as explained elsewhere (p. 283).

Shrubs

Taxus canadensis	*cc*	*Acer spicatum*	*cc*
Corylus rostrata	*cf*	*Acer pennsylvanicum*	*cf*
Ribes prostratum	*cf*	*Lonicera canadensis*	*cf*
Amelanchier sp.	*co*	*Viburnum cassinoides*	*cf*
Nemopanthus mucronata	*cf*	*Viburnum pauciflorum*	*fo*

Herbaceous Vascular Plants

Phegopteris Dryopteris	*fl*	*Oxalis Acetosella*	*cc*
Phegopteris polypodioides	*cf*	*Aralia nudicaulis*	*cc*
Pteris aquilina	*cf*	*Cornus canadensis*	*cc*
Aspidium spinulosum var.	*fo*	*Moneses uniflora*	*cf*
Osmunda cinnamomea	*cf*	*Pyrola secunda*	*co*
Osmunda Claytoniana	*ff*	*Monotropa uniflora*	*co*
Clintonia borealis	*cc*	*Monotropa Hypopitys*	*co*
Maianthemum canadense	*cc*	*Epigaea repens*	*cf*
Streptopus roseus	*co*	*Chiogenes hispidula*	*cc*
Habenaria obtusata	*cf*	*Trientalis americana*	*cc*
Epipactis sp.	*co*	*Linnaea borealis americana*	*cc*
Listera cordata	*fo*	*Solidago macrophylla*	*ff*
Coptis trifolia	*cc*	*Aster acuminatus*	*cl*
Mitella nuda	*cl*		

Except for occasional colonies of the yew, the shrubs and herbaceous vascular plants in the undergrowth seldom form dense masses of vegetation. The ground is usually occupied by a continuous but rather open growth of the various species mentioned above. As on Isle Royale, the most conspicuous element in the herbaceous ground-cover is the bryophyte contingent, whose profuse development here in these coniferous forests is in striking contrast to its paucity in the deciduous climax forests of the lowland. Almost everywhere the ground is overlain by a soft, verdant carpet of *Bazzania trilobata, Hypnum Schreberi,* and *Hylocomium splendens,* with which are associated *Dicranum undulatum, Rhytidiadelphus loreus, R. triquetrus, Ptilium crista-castrensis* and species of *Sphagnum.* In the drier places the hypnum alone may predominate, in moist situations the sphagnums. Ordinarily all the species mentioned, except perhaps the sphagnums, are well represented. The ecological significance of

this bryophyte ground cover in hindering evaporation and impeding drainage, thereby influencing not only the moisture of the substratum, but also its temperature, aeration, and toxicity, can hardly be questioned. Usually the surface layer of living plants is underlain by a more or less spongy mass of incompletely decomposed vegetable remains (the duff), which commonly is six inches or more in thickness. Corticolous liverworts and mosses in general are much more poorly developed in coniferous than in deciduous climax forests, although the lichens occupy a prominent position, particularly the beard lichen (*Usnea barbata*), which in well-lighted situations commonly drapes itself in graceful festoons from the branches of the trees.

Reproduction of the climax trees.—In his ecological investigation of the northeastern evergreen-coniferous climax forest, as developed on Isle Royale, Cooper ('13, pp. 42, 43) arrived at the following conclusions, which were based in large part on the intensive study of carefully selected quadrats. For successful reproduction the balsam fir requires abundant light, given which it will germinate and thrive in any sort of situation. In the forest, reproduction is practically confined to the openings caused by windfall. "The forest is a complex of windfall areas of differing ages, the youngest made up of dense clumps of small trees, and the oldest containing a few mature trees with little young growth beneath. The history of a windfall area is as follows. After the débris has disintegrated sufficiently to allow abundant light to reach the ground, a new generation of trees springs up, approximately even-aged, composed of the three dominant species [balsam fir, white spruce, and paper birch], *Abies* always greatly preponderant. During the continued development of this group most of the individuals are at various times eliminated, . . . Because of the dense shade no new individuals can start beneath them and the final outcome is a group composed of a few large trees, approximately even-aged, in which *Abies* has nearly or quite lost its position of dominance to *Betula*." The resultant forest is thus "a mosaic or patchwork which is in a state of continual change." Yet "the forest as a whole remains the same, the changes in various parts balancing each other."

Turning now to northern Cape Breton, it would seem that the ecological relations of the balsam fir here are somewhat different

from those just described for Isle Royale. Here, as there, openings due to windfall are a characteristic feature of the forest; and the immediate sequel to windfall is a commonly prolific crop of balsam. Some of the young trees may originate from seeds shed previously to the windfall, but which have been lain dormant on the ground for want of conditions suitable to germination. Others doubtless arise from seeds shed only a short time before the windfall, or else contemporaneously with or subsequent to it. But many of the young trees represent specimens which were already present in the forest previous to the windfall. For while the reproduction of the balsam is most prolific in the windfall areas, it is by no means confined to them. It is seldom that the shade on the forest floor is sufficiently dense to prevent reproduction, and almost everywhere the undergrowth in a forest of the climax type includes numerous small, scattered balsams, mostly suppressed but ready to take advantage of any chance opening which may occur in the canopy overhead. Such openings, to be sure, are commonly due to windfall, since except in protected situations the balsam seldom dies a natural death. It is a not infrequent occurrence for groups of trees to be overthrown by the wind, thus giving rise to openings of considerable extent, but more commonly it is only scattered individuals which are blown down at one time. The influence of the openings thus created is probably twofold: (*1*) more light is introduced into the lower layers of vegetation, and (*2*) wherever sunlight reaches the forest floor the moss carpet, together with the more or less spongy underlying layers of duff and humus, tend to become somewhat dried out and in consequence warmer and better aerated. This latter indirect influence, the possible significance of which is suggested by Cooper ('13, p. 20), it seems to the writer, is of fully as great importance here in northern Cape Breton, at least so far as the balsam is concerned, as is the direct influence of increased illumination. The understory of balsams in a deciduous forest is much more thrifty than that in a coniferous forest, a circumstance which might be explained by the more favorable soil conditions there: so far as shade is concerned, this is generally greater in a deciduous than in a coniferous forest, at least during the growing season. But without question increased illumination is a very important direct factor, and perhaps the most important one, affecting the growth

of the balsam. In this connection attention may be called to earlier remarks (p. 285) regarding the ecological relations of the balsam.

The white spruce and paper birch are much more dependent on an adequate light supply for successful reproduction than is the balsam fir. This is demonstrated by the relative abundance of the young growth of these two species in a windfall area or clearing, as contrasted with the great scarcity of any but large trees in the forest. In the case of the paper birch, to quote Cooper ('13, p. 22), "low birth-rate is compensated by a very low mortality and it is thus able to maintain itself in making a good proportion of the mature stand." The same observation may apply equally well to the white spruce, which apparently is relatively more abundant here than on Isle Royale. The black spruce grows best in well lighted situations, but, like the balsam, it is capable of maintaining itself for years in moderate shade.

With reference to their tolerance of shade in this climate, the writer would arrange the climax trees of the northeastern coniferous forest climatic formation in northern Cape Breton in about the following order: paper birch and aspen (very intolerant), white spruce (intolerant), balsam fir, black spruce, and mountain ash (tolerant), and yellow birch (very tolerant).

III. THE EDAPHIC FORMATION-COMPLEX OF THE REGION

A. Preliminary Observations

One of the most perplexing features of this region, when it comes to the exact analysis and delimitation of the various formation-types, is the manner in which these overlap and intergrade. This condition is attributable primarily to the abundance of atmospheric moisture. In less humid climates soil moisture plays an all important rôle in determining the character and distribution of vegetation, and as a result differences in soil and topography are associated with corresponding differences in plant cover. In general it can be stated that the influence of soil and topography on the character and distribution of plant associations is least pronounced in humid climates; most pronounced in arid climates: or, in other words, that this influence is inversely proportional to the dryness of the climate. This tendency toward uniformity in a humid region is of course due in part to the fact

that here many soils, which in a less humid region would be too dry to permit the development of the types of association which characterize the better soils, are kept constantly moist. It may also be due to the fact that bare rock outcrops, which in themselves are unable to retain water except in crevices, become rapidly overgrown, except where they are too steep, by a layer of lichens and bryophytes which create a water-retaining substratum and thus tend to produce ground conditions similar to those found in soils which naturally would be more favorable to plant growth. In the coniferous forest region of northern Cape Breton, and probably in other similar regions as well, this tendency toward uniformity is accentuated by the fact that in the upland forests, owing largely to the prolific development of mosses and liverworts and the copious accumulation of humus, not only is the substratum kept constantly moist, but it is invariably acid to litmus, thus approximating the conditions which prevail in bogs and in the majority of the swamps. In less humid climates, many of the species which here are characteristic of uplands, or which grow both on uplands and in bogs and swamps, are restricted to situations of the latter sort. The tendency for different edaphic formation-types to merge into one another is exhibited to some degree in the lowland region of northern Cape Breton; it is quite pronounced in the forested portion of the highlands; but it reaches its culmination in the barrens, where it is almost impossible to draw a sharp line between the vegetation of uplands and that of the swamps.

B. Formations of the Xerarch Series

1. The Formation-types of Ordinary Uplands in the Forested Region

a. The association-complexes of well-drained uplands

In comparing xerarch successions on ordinary, well-drained uplands here with those of the lowland, the most striking difference is seen in the character of the climax association-type. There, a balsam fir–spruce–paper birch forest may represent merely a passing stage in the succession: in all edaphically favorable situations it is a temporary association-type, destined in the course of time to be superseded by a forest of the deciduous type. Here, however, a forest of this sort represents

the culminating stage in the succession: it is a permanent association-type. Throughout most of the forested region in the highland this coniferous forest climax has been attained, and it is only in edaphically unfavorable situations or in places where the original forest has been destroyed by fire that the more primitive stages in the succession are encountered. The association-types of exposed hilltops may resemble those of similar situations in the barrens, but, on the whole, the sequence

FIGURE 50.—Low coniferous woodland on plateau west of Ingonish.

and general character of the preliminary successional stages in the highland is essentially similar to what has been described for the lowland and therefore need not be discussed further. As a rule the succession takes place rapidly, the trees of the climax forest being present from the outset, and the various stages are more or less telescoped.

b. THE ASSOCIATION-COMPLEXES OF POORLY DRAINED UPLANDS

Forests of the regional climax type attain their optimum development on well-drained slopes. But over a considerable portion of the forested region the country is flat or rolling, with a tendency to be poorly drained, and the prevailing type of vegetation here is low, more or less swampy woodland (FIG. 50). No

sharp line can be drawn between woodlands of this description, which constitute an edaphic climax association-type, and forests of the regional climax type. Essentially the same species may be present in both cases. Here, however, the trees average scarcely twenty-five feet in height, and black spruce may be quite as abundant as balsam, while swamp species, notably *Osmunda cinnamomea* and the sphagnums, commonly predominate in the undergrowth. Associations of this sort may originate through a

FIGURE 51.—Summit of low hill in barrens; mountains west of Ingonish; vegetation in immediate foreground, dwarf shrub heath; in mid-distance (vicinity of figure and beyond), mainly dwarf shrub–spruce heath. The low, bushy spruce in center foreground was about 150 years old.

hydrarch successional series, but more commonly the pioneer stages are xerophytic, the swampy condition being induced very largely through the activity of vegetation in retarding drainage. Parts of the plateau occupied by barrens are commonly skirted on all sides by low woodland, which forms a transition zone between these areas and those congenial to forests of a more mesophytic character. Raised bogs have been developed locally on uplands in the forested region, but these are especially characteristic of the barrens and will be discussed under that head.

2. The Formation-types of Ordinary Uplands in the Barrens

a. THE ASSOCIATION-COMPLEXES OF WELL-DRAINED UPLANDS

The rock face–crevice complex.—Over most of the plateau the bed rock is covered by a thin soil which may be residual or extraneous in its origin. Here and there, however, rounded knolls or blocks of granite and syenite rise conspicuously, and on these may be found rock-face and crevice associations essentially similar to those which have been described as characteristic of rock outcrops in the lowland.

But the prevailing pioneer type of vegetation on uplands in the barrens is some sort of a heath. In the heath the lichens, notably the cladonias, are invariably conspicuous, while sedges and grasses, shrubs and scrubby trees occupy a position of varying importance.

The dwarf shrub heath association-type.—This is characteristically developed on exposed hill tops, where the soil may support only the scantiest kind of a plant cover (foreground of Fig. 51). In such situations the ground in places is bare; elsewhere it is overlain by a sparse mat of cladonias and *Racomitrium lanuginosum,* or maintains a stubby growth of *Polytrichum juniperinum, P. piliferum,* and *Ceratodon purpureus.* Of the seed plants peculiar to such habitats, *Potentilla tridentata* is worthy of note, but particularly characteristic are the four shrubs: *Empetrum nigrum,* which forms low, sprawling mats; *Vaccinium uliginosum,* which occurs in depressed circular patches; *Vaccinium Vitis-Idaea,* which scrambles over the ground and frequently is intricately interwoven in the lichen mat; and *Vaccinium pennsylvanicum angustifolium,* a form of blueberry only a few inches high. In addition to these, there is usually a scattering of other plants, particularly ericaceous shrubs, all of which are noticeably impoverished.

Typical dwarf shrub heath occurs locally throughout the barrens, but in a pure state is nowhere extensively developed. In exposed situations it may constitute a permanent association-type, i. e., an edaphic climax. But more commonly it seems to represent a temporary stage, destined to be superseded by dwarf shrub–spruce heath, into which it nearly everywhere merges. In places dwarf shrub heath very evidently is a retrogressive type which has arisen subsequent to the destruction of dwarf shrub–

spruce heath; but more commonly it represents a primitive phase. Characteristic plants here, in addition to those already specifically mentioned, are the following:

Lichens

Cladonia alpestris	*Cladonia rangiferina*
Cladonia coccifera	*Cladonia sylvatica*
Cladonia crispata	*Cetraria islandica*
Cladonia pyxidata	*Sphaeophorus coralloides* Pers.

Seed Plants

Juniperus communis montana	*Kalmia angustifolia*
Ledum groenlandicum	*Kalmia polifolia*
Rhododendron canadense	*Melampyrum lineare*

The sedge–grass heath association-type.—This occurs in somewhat moister, less exposed situations than the dwarf shrub heath, as for example, or rather dry slopes. The ground is usually covered by a luxuriant growth of cladonias, which may be replaced locally by *Racomitrium lanuginosum* or occasionally by xerophytic species of *Sphagnum,* such as *S. capillaceum tenellum* and *S. tenerum.* The predominant vascular plants are the sedge, *Scirpus caespitosus,* and the grass, *Calamagrostis Pickeringii.* Other herbaceous plants generally present are as follows:

Lycopodium sitchense	*Cornus canadensis*
Lycopodium annotinum pungens	*Prenanthes trifoliolata*
Deschampsia flexuosa	*Solidago uliginosa*
Melampyrum lineare	*Aster nemoralis*

In addition to these, the woody species characteristic of the dwarf shrub–spruce heath are well represented, but for the most part by small specimens, scattered and relatively inconspicuous. Like the preceding association-type, the sedge–grass heath is nowhere extensively developed, and it displays a constant tendency to pass over into dwarf shrub–spruce heath.

The dwarf shrub–spruce heath association-type.—This is one of the most widely distributed and most distinctive types of vegetation in the barrens. It commonly occupies the upper slopes

of hills (Figs. 51, 52), and in general prevails on well-drained uplands wherever the conditions of exposure are such as to prevent the development of a more mesophytic type of vegetation. At first sight an area occupied by this association-type appears as a crowded, labyrinthine series of low mounds or hummocks, irregular in size and shape, but averaging perhaps from three to ten feet in diameter by from one to two feet in height. The hummocks are densely overgrown with cladonias and support a thick growth of low shrubs, mostly ericads. Depressed, bushy trees, mainly black spruce, scarcely two feet high but spreading

Figure 52.—Dwarf shrub–spruce heath; barrens in mountains west of Ingonish.

out laterally over a radius of several feet, constitute an important element in the vegetation, growing on or alongside the hummocks. Here and there, scattered tamaracks may be conspicuous by reason of the fact that they project somewhat above the general surface level of the surrounding vegetation, which otherwise maintains a nearly uniform height at from two to two and a half feet above the floor of the depressions which separate the hummocks. In typical dwarf shrub–spruce heath, the depressions between the hummocks are open and, aside from the cladonia mat which nearly everywhere covers the ground, their vegetation is scanty.

The following list includes the more characteristic plants of dwarf shrub–spruce heath:

Lichens

Cladonia alpestris	*Cladonia rangiferina*
Cladonia sylvatica	*Cetraria islandica*

Bryophytes

Sphagnum capillaceum tenellum	*Leucobryum glaucum*
Sphagnum tenerum	*Racomitrium lanuginosum*
Ptilidium ciliare	*Hypnum Schreberi*

Vascular Plants

Pteris aquilina	*Cornus canadensis*
Abies balsamea	*Andromeda glaucophylla*
Picea mariana	*Chamaedaphne calyculata*
Larix laricina	*Epigaea repens*
Juniperus communis montana	*Kalmia angustifolia*
Maianthemum canadense	*Kalmia polifolia*
Myrica Gale	*Ledum groenlandicum*
Pyrus melanocarpa	*Rhododendron canadense*
Amelanchier sp.	*Vaccinium canadense*
Empetrum nigrum	*Vaccinium pennsylvanicum*
Nemopanthus mucronata	*Viburnum cassinoides*

Any of the other species mentioned earlier as characteristic of sedge–grass heath may grow here also, but these, for the most part, are confined to the depressions between the hummocks.

The structure of the hummocks (Fig. 53) is extremely interesting. Examination shows them to be due entirely to plant activity. Internally they consist of an intricate mass of incompletely decomposed vegetable débris: the sort of structure commonly referred to as "raw humus." Ordinarily the bulk of the material has been derived from the lichens and from the leaves of the various shrubs which inhabit the surface of the hummock, the whole being bound together by the stems and roots of the surface vegetation. In some cases the sphagnum has contributed very largely to the formation of the hummocks: in one instance the excavation of a hummock two feet high, whose surface vegetation, aside from various shrubs, consisted entirely of *Sphagnum capillaceum tenellum,* showed the whole hummock to have been built up by this moss, whose remains, still in a fine

state of preservation, extended nearly to the bottom, where, at the very base of the hummock and overlying the gravelly substratum, was a thin layer of *Leucobryum* remains. It is evident that for the most part the formation of these hummocks is a result of the combined activity of the lichens, particularly the cladonias, and the ericaceous shrubs. They have arisen somewhat as follows. Previous to their formation the ground was covered by a thin mat of mosses and lichens in which grew vari-

FIGURE 53.—Detail view of hummock in dwarf shrub heath association-type; *Cladonia alpestris, Chamaedaphne, Ledum,* etc.; barrens in mountains west of Ingonish.

ous herbaceous plants and shrubs: essentially the same condition which prevails in sedge–grass heath and which still persists in the open depressions between the hummocks. Where edaphic conditions are favorable the cladonias exhibit a marked tendency to grow upward, but they are unable to do so to any extent without some sort of support. The needed support is furnished by the shrubs which, where they grow close enough together, afford a sort of scaffolding upon or around which the lichens are able to push upward. As the shrubs gradually become buried

below they grow above, at the same time branching more or less profusely. And as the branches become covered over they produce copious adventitious roots, with the result that the original number of physiologically independent individuals, as viewed at the surface of the hummock, becomes multiplied many times. The shrubs, therefore, which cover the surface of a hummock have been derived directly, in large part at least, from pre-existing shrubs: they antedate the hummock itself.[13]

The genetic relationship between dwarf shrub and sedge–grass heath, on the one hand, and dwarf shrub–spruce heath, on the other, has already been suggested. During the evolution of the present association-type, various of the herbaceous vascular plants characteristic of the more primitive stages either disappear or else become in large part or wholly confined to the depressions: to situations where there is no great depth of humus and where the soil relations presumably are more favorable than on the hummocks. This is true, for example, of both *Scirpus* and *Calamagrostis,* and of such forms as *Lycopodium, Potentilla, Solidago,* and *Aster.* At the same time, scrubby trees become increasingly conspicuous.

In its ecological aspect, an association of the sort just depicted certainly approximates very closely dwarf shrub heath, as defined by Warming ('09, pp. 210–214). It agrees in the nature of the underlying soil, in the dominance of lichens and ericaceous shrubs, in the low stature of the vegetation, and in the copious production of raw humus: this latter a phenomenon which, according to Warming, "must be regarded as the most characteristic peculiarity of heath." It would seem to differ from typical heath primarily in the presence of various arborescent species which, in more favorable situations, attain much larger dimensions than here. But while any of the trees of the climax coniferous forest (with the exception of yellow birch and red maple) may be represented here, it is significant that black spruce is invariably predominant; that tamarack, which is practically absent from the climax forest, is usually a prominent constituent; and that, on the other hand, balsam fir, the predominant tree in forests of the regional climax type, is of very subordinate

[13] In this connection, see observations by Ganong, quoted on p. 447.

importance. In its typical development, then, the writer would regard this type of association as a true heath.[14]

Transition from heath to Krummholz.—All intergradations are found between typical dwarf shrub–spruce heath and *Krummholz,* the association-type to be treated next, and in this connection the behavior and ecological relations of the spruce and other evergreen conifers has an important bearing. As the principal species concerned, the black spruce will serve to illustrate the points in question. Like the ericaceous shrubs, this species appears at an early stage in the development of the heath: it is antecedent with reference to the hummocks. Through the death of the primary leader, the extensive development and copious branching of the lateral shoots, and commonly also through vegetative reproduction by layering, it characteristically assumes a low, compact, rounded, shrub-like habit. So closely may one of these bushy spruces conform with the contour of the hummock alongside which it grows that on superficial examination it appears to be growing on the hummock itself; but ordinarily the relationship is very different. For the shade produced by these clumps of spruce has an important local effect on the nature of the vegetation, in that it inhibits the growth of lichens and thereby prevents or checks hummock formation. In some areas the depressions between adjacent hummocks are completely filled in by a dense snarl of scrubby spruces which rise to about the same general level as the low vegetation which tops the hummocks. From a distance the surface contour of

[14] Warming ('09, p. 210) defines heath as "A treeless tract that is mainly occupied by evergreen, slow-growing, small-leaved dwarf-shrubs and creeping shrubs which are largely Ericaceae." But the use of the term is not wholly restricted to such areas. Warming himself recognizes lichen-heath and moss-heath (op. c., pp. 205, 208), and Graebner ('01, pp. 26, 27), while distinguishing as most representative areas of the sort specified by Warming, extends the term to include "not only areas dominated by ericaceous shrubs, but open tracts in which there is neither a good tree growth nor a close grass turf; [in which] ligneous plants dominate, especially low shrubs. [Thus,] what we call pine or oak barrens would probably be included in Graebner's heath" (quotation from Cowles' review of Graebner's book). Applying the term in this latter sense, Harshberger ('11, pp. 165-168) regards the "plains" of the New Jersey pine-barrens as heath. Rübel ('14, p. 237) would restrict the use of the term heath to "ericoid-leaved bushland."

such an area appears quite flat and easy to travel, but one soon learns to steer clear of these "tanglefoot" barrens, as an old trapper who served as guide for the writer aptly termed them, whenever possible. Barrens of this sort obviously represent a transition stage between the dwarf shrub–spruce heath association-type and the *Krummholz* association-type. Not only is the arborescent element in the vegetation present in increased abundance, but the character of the undergrowth is different.

FIGURE 54.—*Krummholz* in immediate foreground, passing into low woodland or forest scrub behind the figure; barrens in mountains west of Ingonish.

For the presence of the spruce not only causes the exclusion of certain species, but favors the introduction of others. Underneath these dwarf evergreen trees, wherever they occur, may be found any or all of the liverworts and mosses characteristic of the climax forest of the region (e. g., *Bazzania, Dicranum undulatum, Hylocomium splendens, Ptilium*), together with various of the herbaceous plants (e. g., *Clintonia, Coptis, Linnaea*).

The Krummholz association-type.—This differs from heath in the following important respects: (*1*) Dwarf, bushy trees

(*Krummholz*) predominate and form a relatively closed stand. (*2*) The lichens which characterize the heath (together with the hummocks which they form) are either absent or else poorly developed, while ericaceous shrubs occur here mainly as an understory and are of subordinate importance to arborescent species. (*3*) The undergrowth approximates that of the climax coniferous forests of the region, essentially the same list of bryophytes, herbaceous vascular plants, and shrubs being characteristic of each. (*4*) The ecological aspect is much more

FIGURE 55.—Low *Krummholz* association-type with scattered tamaracks, many of them dead, projecting up above general level of surrounding vegetation; barrens in mountains west of Ingonish.

mesophytic. In typical *Krummholz* (FIGS. 54, 55) the trees range around three and four feet in height and commonly produce a dense tangle through which it is exceedingly difficult to force one's way. It is a type of association characteristic of situations in the open barrens which are somewhat sheltered from wind. In the opinion of Dr. Harvey, who accompanied the writer in 1916, the *Krummholz* of the barrens in northern Cape Breton is a close ecological counterpart of the *Krummholz* on Mount Ktaadn, concerning which he has written ('03, p. 34): "It seems then that the *Krummholz* forest is almost as mesophytic as the *Picea-Abies* combination . . . . which very evidently is

the climatic mesophytic forest of this district." *Krummholz* differs from forest scrub not only in the lesser height of the trees, and in their more pronounced tendency to approximate the *Krummholz* growth form, but in the lesser abundance of the balsam fir.

Factors responsible for failure of forests to develop.—True alpine conditions are found nowhere in northern Cape Breton. This is evidenced by the complete absence of an arctic-alpine flora. On Mount Franey, the highest measured mountain in Nova Scotia, for example, no species were observed which are not equally abundant at lower elevations, while with the exception of perhaps a few forms such as *Betula pumila, Vaccinium uliginosum,* and *V. pennsylvanicum angustifolium,* the flora of the interior plateau scarcely differs in its composition from that of the upper mountain slopes. The general failure of forests to develop in the barrens can be ascribed very largely if not wholly to edaphic factors, especially to the combined influence of snow and wind during the winter months. Heavy winds prevail on the barrens intermittently at all seasons, but particularly in winter. The primary effect of the wind at this season is to sweep the snow from the more exposed sites and pile it up in the more sheltered situations. Exposed hill crests may be swept entirely bare, while in some of the ravines great drifts fully fifty feet in depth may accumulate. In general, it is apparent that the height of the trees, with the possible exception of the tamarack, is closely correlated with the depth of the snow in winter. In exposed situations any branches which project above the surface of the snow are liable to be killed by excessive transpiration or through the sand-blast-like action of the wind-driven snow. Individual shoots may survive a few mild winters, but then comes a severe winter and they too are killed. In the case of forest scrub, an association-type to be described presently, it is evident that, in spite of the apparently exposed position of the low hills on which it is commonly developed, local conditions favor the accumulation of snow drifts in much the same manner that sand dunes are built up along the seacoast.

Age of dwarf trees.—In this connection, a few observations regarding the ages of some of the dwarf trees may be of interest. The tamarack shown in Fig. 56, situated near the crest of the hill pictured in Fig. 51, was found to have more than 150 annual

rings; and about the same number was counted in a cross section of the trunk of a balsam fir, scarcely three feet high, but with a trunk seven inches in diameter. Knee-high spruces more than fifty years old are common in exposed situations, one of those in the foreground of FIG. 51, scarcely a foot in height, having more than a hundred annual rings.

The forest scrub association-type.—From a distance, many of the low hills in the barrens appear to be well wooded, but closer

FIGURE 56.—Gnarled tamaracks, aged about 150 years, at summit of low hill shown in FIG. 51; barrens in mountains west of Ingonish.

inspection commonly reveals a most remarkable type of association. Because of the size of the trees, many of which may be as much as twenty feet high, it should be classed as forest; yet it is an abortive attempt at forest development rather than true forest. Three trees predominate: the balsam fir, the black spruce, and the tamarack, and one and all are battered and weather-beaten, betraying unmistakably the severity of the atmospheric forces to which they have been subjected. In this connection the dissimilar behavior of the three constituent trees under these adverse conditions is of much interest.

The balsam fir commonly possesses a short, stocky trunk from three to six feet high, according to the depth of the snow blanket. This trunk ranges in diameter up to more than a foot (in one case sixteen inches), and some of the trees must be well over two hundred years old (one six inch trunk showed more than 150 annual rings), an unusual age for the balsam in northern Cape Breton. The total height of the tree may be little greater than that of its stubby trunk: the lateral branches, usually borne in

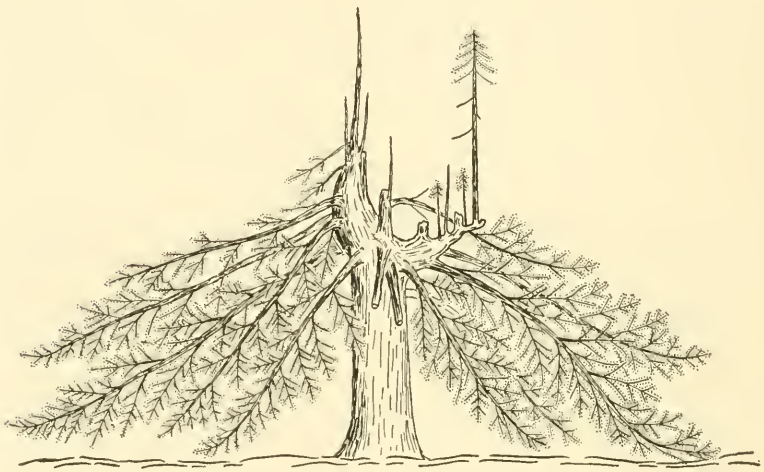


FIGURE 57.—Habit sketch of balsam fir growing in forest scrub association-type; barrens in mountains west of Ingonish. This particular tree is ten feet high (overall) and has a spread of more than a dozen feet with a trunk diameter of nearly a foot.

profusion near its summit, spread out widely, giving rise to a dense, flat-topped crown, low but commonly ten or a dozen feet broad and drooping nearly to the ground. But as a rule, upon the death of the primary leader, a new leader is developed which tends to continue the upward growth of the trunk. After a few years, the length of the interval depending on the severity of the winters, this leader may be killed and replaced by a third, and so on. More than twenty dead leaders have frequently been counted on a single tree. Often several leaders may be active at the same time, but usually one of them soon gains a marked

ascendancy over the others. Very often a leader which rises six or eight feet above the main body of the tree will have had all its foliage blasted away by the wind-driven snow except for a small, pyramidal crown at the very tip.[15] The general aspect of these trees is suggested by the accompanying sketch (FIG. 57).

Usually quite different in its behavior from the balsam fir is the black spruce. In the balsam, while the lateral branches may be capable of assuming the functions of the leader, it would appear that they are able to do so only when very young, and more often than not the leader seems to originate adventitiously from either the main axis of the tree or a lateral branch. In the spruce, on the other hand, the potential capacity for radial growth in the normally dorsiventral lateral branches is much more pronounced, and this capacity is less restricted to the younger branches. Upon the death of the primary leader, a number, often nearly all, of the lateral branches tend to assume the radial habit, thus producing a clump of leaders, all of approximately equivalent rank. As a result, while one leader may sometimes become more prominent than the rest, the spruce commonly acquires a bushy habit quite different from that of the balsam. This dissimilarity of habit in the two trees is often strikingly exhibited in the *Krummholz* association-type: the balsam here is constantly tending to send a vigorous leader up above the general level of the surrounding vegetation and invariably possesses a short, sturdy trunk (FIG. 58); while the spruce adapts itself readily to the prostrate *Krummholz* habit and is virtually devoid of a distinct trunk.

The tamarack behaves differently from either the balsam or the spruce, being apparently better able than these species to withstand the rigorous winter climate. The trees exhibit a gnarled, scraggly aspect, but seldom are killed back to any extent.

Sometimes a forest of the sort under consideration is well nigh impenetrable, and the undergrowth is essentially that of the coniferous climax forest of the region. But more often the trees occur singly or in groups, with open spaces between in which the vegetation is made up largely of the species characteristic of

[15] A different explanation for a similar phenomenon in the spruce has been offered by Ganong ('04, pp. 188, 189).

heath. In general, this association-type is intermediate in character between heath and typical forest.

The ecological status of the tamarack in northern Cape Breton.—The status of the tamarack in the lowland has already been referred to. In the barrens it is a common tree, but throughout the forested region of the highlands it is absent or very rare in

FIGURE 58.—Weather-beaten balsam fir; barrens in mountains west of Ingonish. This tree measured eight feet high (overall) and had a trunk less than three feet high (in position indicated by arrow) but seven inches in diameter and with more than 150 annual rings. The present leader, to left of trunk, shows well the effect of heavy westerly winds (from right in picture) and wind-driven snow.

upland forests, being confined mainly to open swamps. The evident scarcity of this tree in all but open situations is correlated with the fact that it is primarily a pioneer species: it is notoriously intolerant of shade. As a result, except in barrens, swamps, or other open situations, it has almost everywhere been crowded out in competition with the more tolerant climax trees.

The low woodland association-type.—This is essentially similar to the low woodland type of poorly drained uplands described

for the forested region. It may occupy like situations in the barrens, but here it also is a frequent type on moist, fairly well drained hillsides which are protected from the wind.

Summary of successional relations.—It will be seen that in a general way the association-types of well-drained uplands in the barrens have been arranged in an ascending series; that there are all gradations between dwarf shrub heath and sedge–grass heath at the one extreme and typical forest at the other. Incident to the special discussion of the association-types, various successional relationships have been pointed out. But while it is conceivable that in the course of time the associations of relatively primitive types are everywhere destined to become superseded by associations of more advanced types, as a matter of fact this is not generally the case. For the degree of mesophytism capable of attainment in the majority of sites is limited by edaphic factors, and any of the association-types described above may constitute locally an edaphic climax.

b. THE ASSOCIATION-COMPLEXES OF POORLY DRAINED UPLANDS

Although a distinction may be made between well-drained and poorly drained uplands in the barrens, as a matter of fact, as has been intimated earlier, it is practically impossible to draw sharp lines of demarcation. Owing to the character of the vegetation, especially to the influence of the almost universally developed lichen–bryophyte ground cover in retarding drainage, an area which originally may have been well-drained rapidly becomes less so, and there are few areas in which water cannot be squeezed out of a peaty substratum at almost any time of the year.

In protected situations, wet, poorly drained uplands may support low, swampy forests of (mainly) black spruce, with an undergrowth of *Alnus incana, Osmunda cinnamomea,* and the like: forests which might almost equally well be treated under the head of hydrarch successions. Further, the occurrence of sphagnum hummocks in areas occupied by heath has already been mentioned. On flat upland areas from which the water runs off slowly or where it tends to collect locally in shallow rock basins, as well as in various other situations where drainage conditions are such as to favor, at least locally, the development of the sphagnums, bogs and boggy swamps may arise on uplands.

The discussion of these is deferred until later (see under head of raised bogs, p. 433).

3. The Formation-types of Uplands along Streams

THE ASSOCIATION-COMPLEXES OF RAVINES AND VALLEYS

The association-types of ravines.—Streams in the forested region for the most part flow through ravines or broadly V-shaped valleys. The character of the stream-bank and cliff

FIGURE 59.—Low forest in ravine, with barren hill-top above; barrens in mountains west of Ingonish.

vegetation here is essentially similar to that already described for lowland streams. Ravine forests exemplify further the general tendency of the vegetation of uplands in this region toward uniformity, since they differ scarcely, if at all, from the forests of ordinary uplands.

Ravine vegetation in the barrens (FIG. 59), in general, resembles that of the forested region, and the forest-clad slopes here may afford a striking contrast to the barren aspect which prevails on adjoining exposed uplands. In shallow ravines the woodland is low, but in the deeper "gulches" the trees attain considerable size.

The association-types of open valleys.—While practically all the larger streams on their way to the sea run for long distances through deep gorges and ravines, on the plateau itself most of the streams flow through broad, shallow, characteristically flat-floored valleys, but little below the general level of the surrounding country. The slopes which flank these valleys may be covered with low woodland, or in the barrens by *Krummholz*. Their floors are commonly occupied by "hay marshes," alder thickets, and swampy woodland, which will be discussed under hydrarch successions.

C. Formations of the Hydrarch Series

1. The Formation-types of Lakes and Ponds

a. Introductory

Small lakes and ponds of all sizes, but mostly quite shallow, are freely interspersed among the countless low hills which go to make up the surface of the plateau and occur scattered here and there along the seaward slopes of the highland. Many of them lie at the sources or along the courses of the innumerable streams which originate in the barrens, but a large proportion are devoid of any definite outlet. Ponds of the latter type are especially common on the plateau where, owing to the abundant precipitation and the impermeable nature of the rock floor, more or less permanent bodies of water tend to collect in basins of any description. On an undulating, rock-floored table-land such as this, the number of depressions suitable to pond formation is naturally very great, but the number of ponds actually present is even greater. This is due to the fact that, in addition to those whose presence is conditioned by the character of the topography, there are numerous ponds which bear no relation whatever to the topography, whose presence is attributable primarily to the activity of vegetation. The manner in which ponds of this latter sort arise will be discussed in some detail in later paragraphs (p. 449 *et seq.*). On the highland, as in the lowland (while there are plenty of apparent exceptions, particularly in the case of well-drained water bodies) there is a general tendency for lakes and ponds to become clogged up through vegetative activity, and in this way many basins formerly occupied by ponds have become more or less completely filled in.

b. THE ASSOCIATION-COMPLEXES OF WELL-DRAINED LAKES AND PONDS

The plants named in the subjoined list are characteristic of well-drained lakes and ponds in the highland, growing either in the deeper water or in the shallows along the shore. Extended comment seems hardly worth while, since in their local distribution and ecological relations they conform closely with what has been described for similar areas in the lowland.

FIGURE 60.—Shallow pond in mountains north of Barrasois River; aquatic vegetation and narrow marginal fringe of swamp shrubs.

Sphagnum cuspidatum Torreyi
Drepanocladus Sendtneri
Drepanocladus scorpioides
Fontinalis sp.
Isoëtes sp.
Equisetum fluviatile
Sparganium angustifolium
Potamogeton natans
Potamogeton Oakesianus
Carex aquatilis
Carex filiformis
Carex rostrata
Eriocaulon septangulare
Nymphaea variegata
Castalia odorata
Ranunculus Flammula reptans
Nymphoides lacunosum
Lobelia Dortmanna

Dulichium arundinaceum
Eleocharis palustris vigens
Scirpus subterminalis
Utricularia vulgaris
Utricularia intermedia

The character of the marginal vegetation might perhaps more appropriately be considered in connection with swamps, but two phases will be briefly mentioned at this point. Between the water's edge and the adjoining upland vegetation there may occur only a narrow fringe of swamp thicket (Fig. 60), made up of such shrubs as the following:

Myrica Gale
Alnus incana
Spiraea latifolia
Rosa nitida
Ilex verticillata
Nemopanthus mucronata
Chamaedaphne calyculata
Kalmia angustifolia
Rhododendron canadense
Viburnum cassinoides

Elsewhere, however, intervening between this thicket and ordinary summer low water mark there may be a strip of sandy or rocky beach, of varying width, which supports an open swamp association of an essentially pioneer type. Characteristic plants of such a habitat are the following:

Scapania nemorosa
Sphagnum sp.
Lycopodium inundatum
Agrostis hyemalis
Carex filiformis
Carex Michauxiana
Carex Oederi pumila
Carex stellulata
Juncus brevicaudatus
Ranunculus Flammula reptans
Drosera longifolia
Drosera rotundifolia
Hypericum canadense
Hypericum virginicum
Viola cucullata
Viola pallens
Bartonia iodandra
Vaccinium macrocarpon
Lycopus uniflorus
Utricularia cornuta
Aster nemoralis
Aster radula

Very commonly, at least locally, the lake is bordered by swamps of a more advanced type, but these are better considered under the head of swamps.

c. The Association-complexes of Undrained Ponds

In the number and abundance of seed plants, the aquatic vegetation of undrained ponds as a rule is inferior to that of well-

drained ponds. Of species with submerged or floating leaves the most commonly represented are *Nymphaea variegata* and *Castalia odorata, Eriocaulon septangulare, Ranunculus Flammula reptans* and *Utricularia intermedia.* In addition to these, various sedges may grow in the shallow water around the margin or elsewhere, such species as *Eleocharis palustris vigens, Carex oligosperma* and *Scheuchzeria palustris,* together with the buckbean, *Menyanthes trifoliolata.* Of particular importance, however, because of their frequently prolific growth, are the aquatic sphagnums, notably *Sphagnum Pylaisei* and *S. cuspidatum* (including the var. *Torreyi*), and certain filamentous algae. But there is the greatest variation in the vegetation even of closely adjacent and seemingly quite similar ponds. One may be quite choked up with aquatic sphagnums, while in the next there is scarcely any vegetation save a dense growth of algae on the bottom. One may contain a rank growth of *Eleocharis,* its neighbor a similar growth of *Menyanthes,* or neither of these species may be present; and so on. Practically all undrained ponds are mucky at the bottom and along the shores. The dynamics of the vegetation in lakes and ponds are discussed in later paragraphs.

2. The Formation-types of Lake-, Spring-, and Precipitation-swamps

a. THE ASSOCIATION-COMPLEXES OF WELL-DRAINED SWAMPS

As elsewhere suggested, throughout the region of coniferous forests, wherever the ground is sufficiently wet, there is a tendency for the substratum, through the influence of vegetation in obstructing the drainage, to become boggy. In view of this fact, it would not have been at all surprising to find that swamps similar to the undrained type of the lowlands were entirely lacking here. But this is not the case. While the majority of the swamps belong to the undrained or poorly drained types, swamps are frequently encountered which unmistakably are of the well-drained type. The following list of plants, from an open swamp situated on a fairly steep, springy hillside in the forested region, scarcely a mile from the edge of the barrens, is quite characteristic of well-drained swamps in this region: it has been practically duplicated in other similar areas.

Taxus canadensis
Calamagrostis canadensis
Cinna latifolia
Glyceria canadensis
Scirpus caespitosus
Scirpus hudsonianus
Eriophorum virginicum
Rynchospora alba
Carex crinita
Carex flava
Carex stellulata
Juncus brevicaudatus
Smilacina trifolia
Iris versicolor
Habenaria clavellata
Habenaria dilatata
Spiranthes Romanzoffiana
Myrica Gale
Alnus incana
Thalictrum dioicum
Drosera rotundifolia
Spiraea latifolia
Amelanchier sp.
Sanguisorba canadensis
Rosa nitida
Viola blanda
Viola cucullata
Chamaedaphne calyculata
Lonicera caerulea
Viburnum cassinoides
Eupatorium purpureum
Solidago rugosa
Aster acuminatus
Aster nemoralis
Aster puniceus
Aster radula
Aster umbellatus
Cirsium muticum

Aside from relatively steep, springy slopes, swamps of the well-drained type are commonly developed along streams, in places where the ground is subject to occasional inundation (see further under head: formation-types along streams, p. 456). The vegetation in swamps of the well-drained type is apt to include more or less admixture of bog species, as shown by the above list, but these occupy a subordinate position and sometimes even the omnipresent ericad, *Chamaedaphne,* is absent. The only occurrence of *Typha latifolia* noted on the plateau was in a swamp of this description. Well-drained swamps are far less frequent in the barrens than in the forested region, but even here they are by no means absent, particularly along the larger streams.

b. THE ASSOCIATION-COMPLEXES OF POORLY DRAINED SWAMPS

Under this head, here as in the lowland, may be included a large number of swampy areas which, in the character and ecological relations of their vegetation, appear to be intermediate between the well-drained and the undrained types. There is one group of swamps in particular which seems to fit in under this

head better than under any other, swamps which are quite commonly encountered along the shores of well-drained lakes. Locally along the margins of these lakes (Fig. 61) there have been formed broad, nearly level beaches, sometimes twenty-five or fifty feet in width, which lie somewhat above the level of the lake in summer, but are submerged during winter and early spring, at times when the outlet is blocked up by the ice.

At an early period in its development the vegetation in such an area is essentially as described for the beach in connection

Figure 61.—Small, well-drained lake with border of marshy swamp; mountains north of Barrasois River.

with the vegetation of well-drained lakes and ponds (p. 417): an open swamp association of a pioneer type. In the course of time, under favorable conditions, the more or less discontinuous plant cover characteristic of this early stage may become continuous. Largely through the activity of the sedges, *Carex filiformis, Carex oligosperma,* and *Rynchospora alba,* a shallow layer of peat is formed and the level of the swamp's surface is gradually raised higher. It is worthy of special note that the sphagnums play a relatively insignificant part in the building up process: the cushion-forming species so conspicuous in bog

formation are usually absent or poorly developed. About the only form at all abundant is *S. Pylaisei,* a rather delicate species which, with the liverwort, *Cephalozia fluitans,* commonly covers the peaty substratum in among the sedges with a thin, felty mat. At an early stage in its development, in addition to the sedges already mentioned, the vegetation of such an association-type includes, among others, the following species:

Schizaea pusilla
Lycopodium inundatum
Scheuchzeria palustris
Scirpus caespitosus
Rynchospora alba
Rynchospora fusca
Bartonia iodandra
Drosera longifolia
Vaccinium macrocarpon
Utricularia cornuta

As time goes on, *Scirpus caespitosus,* at first scattered, comes to occupy the ground more and more completely, forming a rather dense sward and crowding out most of the species listed above, except such as are able to persist in local depressions. The *Scirpus* is responsible for a still further elevation of the substratum, but the peat in such a swamp is almost invariably shallow, seldom exceeding two feet in thickness. Commonly associated with the *Scirpus* in this association-type are the following:

Calamagrostis canadensis
Carex Michauxiana
Carex pauciflora
Habenaria blephariglottis
Epilobium palustre
Drosera rotundifolia
Sarracenia purpurea
Aster nemoralis

The vegetation is predominantly herbaceous, with *Scirpus* as the character plant. As a rule, however, there is a scattering of low shrubs, such forms as *Myrica, Spiraea, Andromeda, Chamaedaphne, Kalmia polifolia, Rhododendron,* and *Lonicera caerulea,* which, along the shoreward margin, commonly form a thicket. An association of this sort bears a marked resemblance to bog-meadow, as described later in connection with raised bogs. In many situations it seems without question to represent an edaphic climax. Failure for succession to proceed further is probably correlated with an inability on the part of the cushion-forming sphagnums to gain control, an inability for which the periodic inundation seems in some way to be responsible.

c. THE ASSOCIATION-COMPLEXES OF UNDRAINED SWAMPS

Ecological characteristics of the more important bog species of Sphagnum.—Emphasis has been laid earlier on the prominence in bogs of the sphagnum mosses. Allusion has also been made to differences in the ecological relations of various species, in their manner of growth, and in the rôle which they play in bog development. It seems appropriate at this point to sum up briefly, with reference primarily to their ecological relations, the essential features of the more important species of *Sphagnum* which grow in the bogs of this region. These may be divided more or less definitely into five groups, as follows.

Group 1. Plants primarily aquatic, floating at or near the surface of the water. *S. cuspidatum:* commonly yellowish green in color, limp and flaccid, with a delicate, feathery appearance; when growing emersed, stems usually prostrate and trailing or creeping. The var. *Torreyi* is very robust, more rigid than the typical form, and ordinarily a dirty brownish green in color. *S. Pylaisci:* dark purple to nearly black in color; soft and delicate, but as a rule scarcely flaccid; slender, with sparsely developed, short branches; when growing emersed, stems prostrate and trailing or semi-erect; perhaps the most easily recognized of any native sphagnum.

Group 2. Plants semi-aquatic, amphibious; occasionally completely submerged and with a habit similar to that of *S. cuspidatum,* but more commonly with the tips of the shoots projecting well above the surface of the water; quite robust, fairly rigid, erect. *S. Dusenii:* in color, usually green, more or less tinged with yellow-brown. *S. pulchrum:* in color, olive-green to brownish green; commonly grows emersed, forming dense but rather loose, soft cushions (see further under group 4).

Group 3. Plants primarily non-aquatic, commonly growing in low, wet, boggy grounds. *S. tenellum:* erect, slender, fragile, usually occurring in dense, loose masses and forming beautiful, soft, low mats; in color, ordinarily yellowish green; one of the most delicately lovely of all the sphagnums.

Group 4. Plants mainly non-aquatic, though commonly growing in very wet places and occasionally submersed; usually very robust, erect and rather rigid; when emersed, forming dense, rather compact masses and building up fairly firm cushions; submersed forms quite flaccid. *S. papillosum:* in color, generally

brownish to nearly black. *S. magellanicum:* in color, pale greenish white, or usually strongly tinged with pink or purple-red. *S. pulchrum* might perhaps also be classed here. It may be noted, as of contemporaneous interest, that in the selection of sphagnums suitable for making surgical dressings the full-leaved forms of *S. papillosum* and, to a lesser extent, *S. magellanicum* have been found to furnish the best material (in this connection, see Porter '17).

Group 5. Plants strictly non-aquatic, growing in moist or relatively dry situations; erect and mostly slender; forming dense, compact masses and building up firm cushions. *S. capillaceum tenellum:* color commonly a vivid red. *S. fuscum:* color commonly russet-green. *S. tenerum:* color commonly yellowish, or more or less tinged with pink or red.

As grouped above, the species are arranged approximately in the order of decreasing hydrophytism. For purposes of convenience, the species of group 1 may be referred to as aquatic or hydrophytic; those of group 2 as semi-aquatic; those of group 4 as *mesophytic;* and those of group 5 as *xerophytic.* In view of their tendency, of exceeding importance from an ecological standpoint, to form more or less compact cushions, the species in groups 4 and 5 may be distinguished further as "cushion-forming species." The significance of the above classification will be seen presently.

Outline of methods by which bogs arise in water-filled depressions.—Bog formation in water-filled depressions is due largely, if not wholly, to plant activity. In general, as has been indicated elsewhere (see discussion of lowland swamps), there are two methods by which the conversion of a pond into a swamp may be accomplished. These may be designated: (*1*) *filling from within,* and (*2*) *encroachment from without.* By the first method the bottom of the pond is built upward toward the surface through the gradual accumulation thereon of successive layers of organic débris, derived mainly from the incompletely decomposed remains of various aquatic plants. By the second a mat of swamp vegetation, originating on the banks or in the shallow water near the shore, pushes outward over the surface of the water, roughly speaking, into the deeper parts of the pond. In typical instances these two lines of development are quite distinct from one another, and the filling in of a pond may be

accomplished entirely through one or the other. But both processes may commonly be observed in one and the same pond and, as will be shown later, the filling in and obliteration of the pond may frequently be achieved through the combination of the two.

Filling from within, with particular reference to the rôle of various sphagnums.—The commonly active participation in this process of various aquatic seed plants and algae calls for no special comment. Of more interest here is the conspicuous part often taken by certain species of sphagnum. These are particularly important in the barrens where, in the small, undrained ponds which are so abundantly developed and which constitute such a characteristic feature of the plateau, various sphagnums commonly predominate the successive stages of bog evolution from start to finish. It is to the conditions observed in and about these ponds that the following remarks apply. Here, while a subordinate part may frequently be played by various other plants, the bulk of the organic débris by which the pond becomes filled in up to water level is contributed by the two aquatic sphagnums, *S. Pylaisei* and *S. cuspidatum,* associated with which, but in lesser abundance, usually grows the liverwort *Cephalozia fluitans.* During the summer months these two species of *Sphagnum,* either or both, may be present in such profusion as to completely clog the pond to a depth of several inches below the surface with a loose, floating mass of vegetation. One is tempted to regard such a structure as a true floating mat, but such is hardly the case (see, however, in this connection, p. 429). For while the "mat" does float during the growing season, so long as there is open water underneath it sinks to the bottom in winter. It is indeed extremely doubtful whether under any circumstances sphagnum of itself is capable of forming a permanent floating mat, i. e., a raft-like growth sufficiently firm and stable to permit the establishment and maintenance on its surface of a non-aquatic type of vegetation.

Eventually, however, the bottom of the pond may become built up to such a level that, except during periods of high water, the substratum is exposed to the air, and here, in addition to the bryophytes which have been largely responsible for its development and which still cover its surface with a thin, more or less continuous mat, the soft, mucky ground usually becomes popu-

lated by a very characteristic group of vascular plants, among which the following are almost invariably present:

Lycopodium inundatum	*Drosera longifolia*
Rynchospora alba	*Vaccinium macrocarpon*
Eriophorum angustifolium	*Vaccinium Oxycoccus*
Carex oligosperma	*Bartonia iodandra*
Ranunculus Flammula reptans	*Utricularia cornuta*

To this list might be added the curly grass fern (*Schizaea*), which sometimes, and the bog rosemary (*Andromeda*), which frequently is met with in situations of this sort. An important ecological function is fulfilled by the sedges and the cranberries, since through the medium of their roots and stems they reinforce and bind together the mucky deposit, thereby producing a semblance to floating mat formation. For convenience, a mat of this sort, formed over a soft, mucky deposit, may be referred to as a *muck mat.*

Sphagnums of the semi-aquatic group, particularly *S. pulchrum*, frequently put in an appearance while the rising substratum is still covered by some depth of water. In such cases the succession may be modified to such a degree that the muck mat stage is omitted. For these semi-aquatic species, growing in fairly dense masses, their stems erect and projecting slightly above water level, are able to eliminate, probably through the influence of shade, the lower, more truly aquatic sphagnums. Associated with the sphagnums in such a habitat may grow, locally in abundance, *Scheuchzeria, Eleocharis, Carex limosa, Smilacina trifolia* and *Menyanthes.* These may fulfill here a function similar to that performed by sedges and cranberry in the case of the muck mat, where also they are not infrequently represented.

Returning to the consideration of the muck mat: the sphagnums of the aquatic group are incapable of building up the surface to any appreciable height above ordinary summer water level, although to a limited extent this may be accomplished by the sedges. Further elevation is dependent primarily on the advent of the more mesophytic sphagnums. For some reason, the prostrate, felty tangle of aquatic sphagnums and *Cephalozia*, which commonly covers the surface of the muck mat, seems to hinder the rapid establishment of other bryophytes, and in

consequence this stage may be protracted for a long time. But sooner or later other sphagnums may secure a foothold and eventually gain the upper hand.

In general, the elevation of the bog surface above water level is accomplished very largely through the activity of species of *Sphagnum* which possess to a more or less marked degree the cushion-forming habit, but the process is greatly facilitated by the concurrent activity of the vascular plants growing on the sphagnous substratum, since these, in the manner already suggested, bind together and consolidate the sphagnum cushions, and in addition may form a sort of scaffolding which expedites the upward growth of the mosses. *Sphagnum pulchrum* with its semi-aquatic habit is a common pioneer on the muck mat, and with its erect habit of growth and tendency to form loose cushions is able to build up the surface to some height. Fully as important at this stage, and subsequently much more so, are *S. papillosum* and *S. magellanicum,* species with a generally more robust habit and a tendency to form denser cushions than *S. pulchrum*. Any of these three species may act as pioneers, and frequently all of them grow intermixed.

Once the cushion-forming sphagnums have firmly established themselves, the bog surface may be built up quite rapidly. A measure of the rate at which this takes place is sometimes afforded by shrubs which have been buried by the rising substratum. To cite a specific example, in an erect stem of *Myrica Gale* which had been partially buried to a depth of eight inches a discrepancy of seven years was found in its age near the bottom of the deposit (ten years), and at the surface (three years), a fact which would seem to indicate that here the sphagnums had grown upward at the rate of about an inch a year.

As the surface rises higher, the mesophytic sphagnums (*S. papillosum, S. magellanicum*) may gradually crowd out their more hydrophytic competitor (*S. pulchrum*). The height to which these two species are able to build up the substratum varies, being apparently conditioned in part directly by soil moisture relations, but largely by competition on the part of other species. For with its increasing elevation the substratum naturally becomes somewhat drier and consequently less congenial to the mesophytic species, while at the same time conditions become more favorable for relatively xerophytic species, such as

S. fuscum and *S. capillaceum tenellum,* which, while they may frequently be present, do not thrive in the wetter situations. These xerophytic sphagnums, at first growing intermixed with the mesophytic species, gradually become more abundant, overgrowing and eventually eliminating their less xerophytic competitors. The mesophytic cushion-forming sphagnums may be largely responsible for the elevation of the bog surface to a height of a foot or two above the original water level, but any

FIGURE 62.—Margin of small undrained pond near crest of raised bog; barrens in mountains west of Ingonish; in foreground, *Andromeda* and other shrubs advancing into the pool.

further upward growth is dependent very largely on the xerophytic cushion-forming sphagnums, which invariably are the predominant species in a mature bog.

Encroachment from without, with particular reference to the formation of floating mats.—In its essential features, floating mat formation in the highlands differs little from what has been described for the lowlands. The pioneers may be either shrubs or sedges. In the former case (FIG. 62), here as there, unless the framework created by the shrubs becomes overgrown by sphagnums, mat formation proceeds no farther than this incipient

stage. The important sphagnums in this connection are *S. pulchrum* and the more mesophytic cushion-forming species, but particularly the latter. As a rule these are present in abundance, and so favorable are the conditions for their growth here in the highlands that they commonly give rise to a thick mat which rises steeply from the water's edge to a height of one or two feet. *Myrica Gale, Chamaedaphne,* and *Andromeda* are all important as pioneer shrubs, now one, now another playing the leading rôle.

Locally certain sedges are more important as pioneers in mat formation than are the shrubs. *Carex limosa* frequently extends out into the open water from along the shore, growing in length as much as a foot in a single season, and sometimes it is present in sufficient abundance to form the basis of a mat. More commonly *Carex filiformis* is the pioneer sedge. The behavior of this species in mat formation has been described by Ganong ('03, pp. 440–441), Transeau ('05-'06, p. 363), Davis ('07, 135–138), the writer ('15, pp. 198–199), and others. Commonly the sedges are followed by the sphagnums, which build up the surface in the manner already described. On the whole, sedges are much less prominent in the rôle of mat pioneers than are shrubs. Moreover, the latter, because of the framework afforded by their strong, woody stems, favor much more the growth of the cushion-forming sphagnums and the consequent thickening and solidifying of the mat.

As the mat grows outward into the pond, the open water beneath gradually becomes filled in, partly by the sinking of the mat as it becomes thicker and heavier through the continued upward growth at its surface, partly by the dropping down of vegetable débris from the under surface of the mat. Where the outward growth is rapid, the mat may be underlain for some distance shoreward from its outer margin by open water; where outward growth is slow the filling in beneath may keep pace with it, so that very little of the mat is actually floating. But in either case, wherever the filling in is being accomplished primarily through the intervention of a floating mat, the water in the pond is deep right up to the edge of the mat, and in cases where the mat has become "grounded" clear to its margin, in the manner indicated above, the bank usually sheers precipitously to the bottom.

A somewhat puzzling modification in floating mat formation is exhibited in particular by many of the small ponds in the barrens. Commonly the encroaching banks advance at a more or less uniform rate into the pond from one or several sides, but frequently the rate of advance varies locally, and to such an extent that the marginal bog comes to project out into the pond in triangular or tongue-shaped masses (Fig. 64). Through the continued spread or coalescence of such masses a relatively large pond may become subdivided into several smaller ones: in one case noted a group of nine small ponds had thus originated. This singular behavior is not correlated with any differences in the depth of the water, and for a long time the author was at a loss for an explanation. The solution, however, appears to be somewhat as follows. Attention has already been called to the fact that in the small, undrained ponds of the barrens, the surface during summer is commonly occupied by a floating mass of aquatic sphagnums. In winter this mass sinks to the bottom. Here the loose tangle may become intergrown with various filamentous algae to such an extent as to render it impervious to gases, and the following spring it may be floated toward the surface as a result of gas accumulation underneath or within the mass. Cases of this sort have been frequently noted. As a rule, only portions of the mass actually reach the surface, and on the substratum thus presented sedges or shrubs may gain a foothold, thus inaugurating what essentially is a floating mat. Very often, as might be expected if this explanation is correct, peninsulas and islands of bog are encountered in these ponds. In this connection, see Powers' paper on "Floating Islands" ('14).

Encroachment from without in combination with filling from within.—It commonly happens that the conversion of a pond into a swamp is accomplished through a combination of the two methods of filling just described. The filling in up to the surface level may be due largely to the activity of aquatic vegetation, and it is on the substratum thus formed that the mat advances. In this connection the conditions observed around a small, nameless lake, near the upper limits of the forested region, and studied with some care will serve as an illustration. The lake covers an area of perhaps two acres, has roughly the shape of a rounded equilateral triangle, and is drained by a small, sluggish stream.

Its original size has been reduced about one-half by the centripetal encroachment of the bogs which now surround it to a variable width on all three sides. In the still open part of the pond, the bottom seems to be completely covered by a soft, mucky deposit which in places must be many feet thick. This deposit without question has been formed almost wholly through the accumulation on the floor of the pond of vegetable débris, which in large part has been derived from the remains of aquatic seed plants, mosses, and algae. In proceeding from the middle of the lake toward the shore, the depth of the water gradually diminishes, the mucky bottom sloping gently upward until, just before the lakeward margin of the bog is reached, it nearly or actually reaches water level. On the substratum thus produced a mat has been formed, which has advanced from the shore out into the lake as rapidly as the filling in process has permitted. And in this connection considerable interest attaches itself to the divergent courses of development which have ensued on two of the three sides of the lake.

Along one side a sedge mat has pushed its way out for a distance of a dozen or fifteen feet from the original shore. For the development of this mat three plants have been primarily responsible, namely *Carex filiformis, Rynchospora alba* and *R. fusca,* and these are still the predominant forms, practically the only other species present being *Utricularia cornuta, Drosera longifolia,* and *Sphagnum Pylaisei.* The mat is flat and firm, and, although it is but a few inches above ordinary summer water level, one can walk dry-shod almost to its edge.

Along the other shore the behavior is somewhat different. The shoal water along the margin of the advancing bog is occupied by an association made up very largely of the mosses, *Sphagnum pulchrum* and *Drepanocladus Sendtneri.* These are present in sufficient abundance to form a low, wet substratum upon which the sedges, *Carex filiformis* and *Rynchospora alba,* together locally with *Andromeda,* gain a foothold. Thus there is formed a low mat which paves the way for further progress. But subsequent development is not always the same. It may follow one of two courses, and which of these it shall be seems to depend very largely on which species of *Sphagnum* gains control over the situation. Along much of the shore *S. papillosum*

establishes itself and with *S. pulchrum,* which is already present, rapidly builds up the surface to a height of a foot or more above water, at which level *S. fuscum* begins to assert itself. In this way there arises a typical bog (Fig. 63), in which the cushion-forming sphagnums and their customary vascular associates prevail. Locally, however, the low mat is usurped by *Sphagnum Pylaisei.* This sphagnum, it should be remarked, while it grows profusely in many small undrained ponds, is seldom a conspicu-

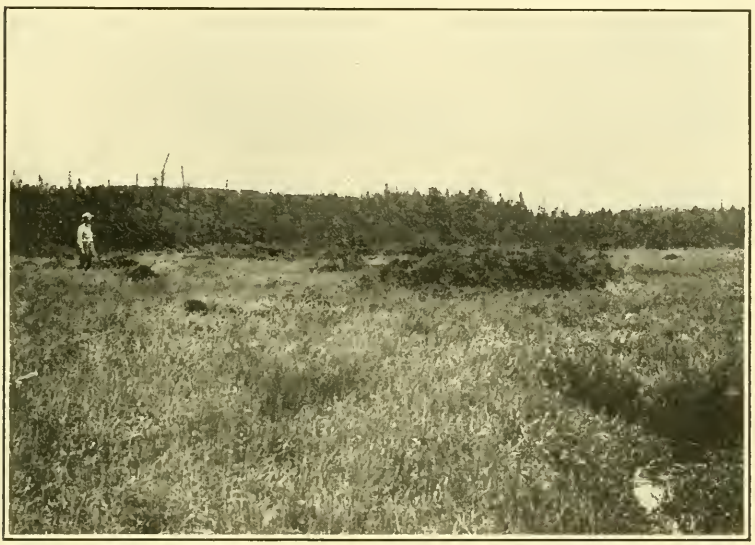


Figure 63.—A characteristic bog in the mountains west of Ingonish: sedges, ericads, and sphagnums predominant, with scattered clumps of black spruce.

ous element of the aquatic vegetation in ponds of any size, like the present one, especially where they are well drained. But it frequently occurs in the swamps which border them. Along with *S. Pylaisei* commonly grows the liverwort, *Cephalozia fluitans.* These two bryophytes, as elsewhere suggested, tend to form a rather compact, felty growth over the substratum, which seems in some inexplicable manner to hinder the invasion of these areas by the cushion-forming sphagnums. So tenaciously, indeed, may they hold their own that, as the contiguous higher

portions of the bog push out into the pond, these lower areas commonly become completely engulfed. The vegetation of the hollows thus formed is strikingly different from that in the surrounding bog, being essentially similar to that of the muck mat described in earlier paragraphs. In addition to the two sedges, *Carex filiformis* and *Rynchospora,* the following vascular plants are characteristic: *Schizaea pusilla, Lycopodium inundatum, Carex oligosperma, Ranunculus Flammula reptans, Drosera longifolia,* and *Utricularia cornuta.* Ultimately these depressions seem destined to become incorporated with the rest of the bog, but they may persist virtually unaltered for a long time. The usual forerunner of the typical bog vegetation is *Scirpus caespitosus,* and this sedge seems to pave the way for the cushion-forming sphagnums which ultimately gain control.

It has already been noted that in the small ponds of the barrens, where the aquatic sphagnums play such an important part in the filling process, the mucky substratum which these form, with its felty cover of *Sphagnum Pylaisei, S. cuspidatum,* and *Cephalozia,* may similarly persist virtually without further change for a very long time. It may be added here that very commonly such areas are gradually being reduced in size and seem destined to extinction through the slow centripetal encroachment of the steep, peripheral banks of sphagnum.

The method of filling which has been described in the preceding paragraphs differs from that previously described as due entirely to "filling from within" mainly in the more obvious centripetal encroachment of the marginal swamp vegetation. As a matter of fact, there is scarcely any real distinction, for, strictly speaking, as soon as the bottom of a pond has been built to the surface through the activity of the aquatic plants, any further changes are invariably due to the invasion of plants from without.

The climax association-type of bogs.—Extended comment is hardly necessary. The character of the climax association-type varies locally, but in general it is marked by the predominance of sphagnums and ericaceous shrubs, with black spruce and tamarack. In many cases the vegetation of ordinary bogs in the highland is scarcely different from that described for lowland bogs, while in others it closely approximates the conditions found in raised bogs which will be described next.

d. THE ASSOCIATION-COMPLEXES OF RAISED BOGS

Geographical distribution of raised bogs in eastern North America.—Bogs of the raised (*"Hochmoor"*) type (FIGS. 64, 66) are extensively developed in parts of northern Europe, and there are numerous published accounts dealing with them, both from an economic and a biological standpoint. But concerning their occurrence and distribution in North America little is known, and specific references to them in the literature are scarce.

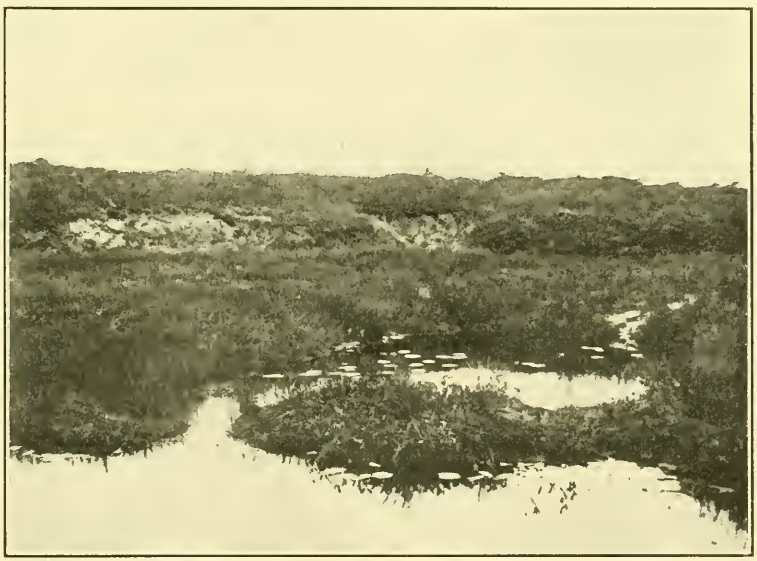


FIGURE 64.—Raised bog on Peter's Barren, in the mountains east of Frizzleton; in the foreground, pond and low, wet bog; in the background, the more elevated part of the bog, which rises more than twelve feet above the pond level.

Ganong, more than twenty-five years ago ('91), called attention to the presence in New Brunswick of bogs of this type, and in 1898 he published a rather detailed account of the raised bogs in the southern part of this province. He has also made some brief notes ('06[b]) on the raised bogs of Miscou Island, New Brunswick. In his second paper, Ganong indicates the reported occurrence of raised bogs in Nova Scotia and Anticosti, and the probability of their occurrence in Newfoundland. In a recent

publication ('15), the third of a series of papers on the economic aspects of peat bogs of Canada, Anrep, speaking of the Clyde Peat Bog in Nova Scotia, states (p. 55) that "this is the first 'high moor' bog encountered during the last six years of investigation" (a period during which he had studied numerous bogs in Manitoba, Ontario, and Quebec). Davis, in discussing the origin of the Maine peat deposits (Bastin & Davis, '09), gives a short description of the manner in which raised bogs are formed and of the relation between "built-up deposits" and "filled-basin deposits." The former, corresponding to the raised bog, appears to be a not infrequent type of swamp along the Maine coast as far south as the vicinity of Portland, and evidently it is of quite common occurrence northeastward. On the whole, judging from the data at hand, both published and unpublished, it would appear that in eastern North America raised bogs are largely confined to Newfoundland and to those parts of eastern Canada and Maine which are in the proximity of the sea-coast. Their limitation to this region is unquestionably correlated with the character of the climate: the abundant precipitation, relatively low atmospheric humidity, cool summers, and the absence of extreme low winter temperatures such as prevail farther inland. The paucity of literature dealing with raised bogs in this country is doubtless attributable, as Ganong suggests, to their remoteness from botanical centers and their hitherto little appreciated economic value. In Europe, "great bogs occur within easy reach of the botanists of Germany, Switzerland, and Scandinavia, and their great economic value has led to their exhaustive study both by individual workers and by government commissions" ('98, p. 131).

From the brief examination which the author was able to make of the Spruce Lake bog and two neighboring smaller bogs about a dozen miles west of St. John, New Brunswick, it may be stated that the raised bogs of this region, as described by Ganong, are essentially similar to those of northern Cape Breton.

Occurrence of raised bogs in northern Cape Breton.—In this particular region raised bogs apparently are confined to the plateau, but this is very likely due to edaphic rather than atmospheric factors, since in southeastern Cape Breton fine raised bogs occur at but little above sea-level. On the highlands in northern Cape Breton raised bogs are encountered here and there in the

forested region, but their greatest display is seen in the barrens. To the study of the origin, development and ecological relations of the raised bogs here the author has devoted considerable time, and it is hoped that the facts set forth in the following pages may contribute materially to the knowledge of this fascinating swamp type, as developed on this continent.

General features of raised bogs and the influence of edaphic factors on their local distribution.—The most bizarre feature of a raised bog is the fact that it is higher toward the center than toward the margin: the surface is convex, and the entire structure frequently presents more or less the form of an inverted saucer or watch-glass. The outline of a typical raised bog, as viewed in cross section, is shown by Fig. 65, *B*. In this connection, it might be remarked that a slight convexity in the contour of the surface is perceptible in some of the lowland bogs of northern Cape Breton, and similar conditions are occasionally noted in southern New England; but in these cases the elevation of the middle portions at most is only a foot or two. In the case of typical raised bogs the difference in height between margin and center may be many feet: viewed from the surface alone, and disregarding the contour of the underlying rock floor, the higher portion may rise to a height of from fifteen to twenty or more feet above the lower marginal portions. But that the actual elevation of the bog surface above the rock substratum in reality is often much less than it appears from superficial examination will be apparent later. As shown by the cross section (Fig. 65, *C, f-h*) the surface rises rather abruptly from near the margin, then more gently, and the top of the bog may be practically flat. The angle of slope along the steeper flanks of a bog varies locally, but ordinarily the surface rises at the rate of about one foot to fifteen or twenty on the level. Sometimes, however, the slope is much steeper: in one extreme instance (foreground of Fig. 64), for example, a rise of three feet in three and six feet in twelve was noted. The bogs vary in size, but commonly they are many acres in extent, and in some cases they stretch out uninterruptedly for more than a mile. On the higher levels of the bog the ground underfoot, for the most part, is quite firm and springy, but locally, particularly in the vicinity of the small ponds which are frequently present, it may be soft and spongy. The character of the surface vegetation

will be discussed in detail later: suffice it to state here that in addition to the sphagnums which form the groundwork of the mass, the most prominent plants are low, ericaceous shrubs and the sedge, *Scirpus caespitosus*.

For the development of a raised bog, the fundamental prerequisites are the presence of certain species of sphagnum and of environmental conditions congenial to their growth, since from start to finish in the evolution of such a bog these mosses play an all essential rôle. Of foremost importance is a copious water supply, and this is controlled partly by climatic, partly by edaphic conditions. Of the water which falls on the earth's surface in the form of rain and snow, part enters the ground, forming the ground water supply; part runs off over the surface into streams and lakes; the remainder is evaporated or is absorbed directly by vegetation. In so far as the development of raised bogs is concerned, it is now generally recognized that the chief source of their water supply is meteoric, rather than telluric. In other words, while locally a limited amount of the water needed may be derived from springs, on the whole their distribution and growth is independent of the ground water supply. Surface drainage from neighboring slopes may and frequently does help out, but in the large it is the water precipitated directly upon the surface of the area occupied, in the form of either rain or snow, which is most important. Swamps which thus are dependent directly upon atmospheric precipitation for their water supply have been designated precipitation-swamps, by way of distinction from spring-swamps and lake-swamps (see earlier remarks, p. 354).

The importance of edaphic factors is seen in their influence on water loss through surface runoff and downward percolation. Given a substratum sufficiently impermeable to prevent loss through percolation, a raised bog may originate under quite varied topographic conditions. In general, it may be built up either in and around a water-filled rock basin or over any essentially flat, undulating or irregular surface from which the rain and snow water tend to run off slowly or to accumulate in local depressions. Such surfaces as the latter, considered in their entirety, may be either approximately level or slightly inclined. It is probably the lack of suitable areas of impermeable substratum that is responsible for the observed absence of raised

bogs in the lowland. In the highland the substratum underlying the raised bogs is practically impervious granite rock, bare, or thinly covered by a gravelly soil.

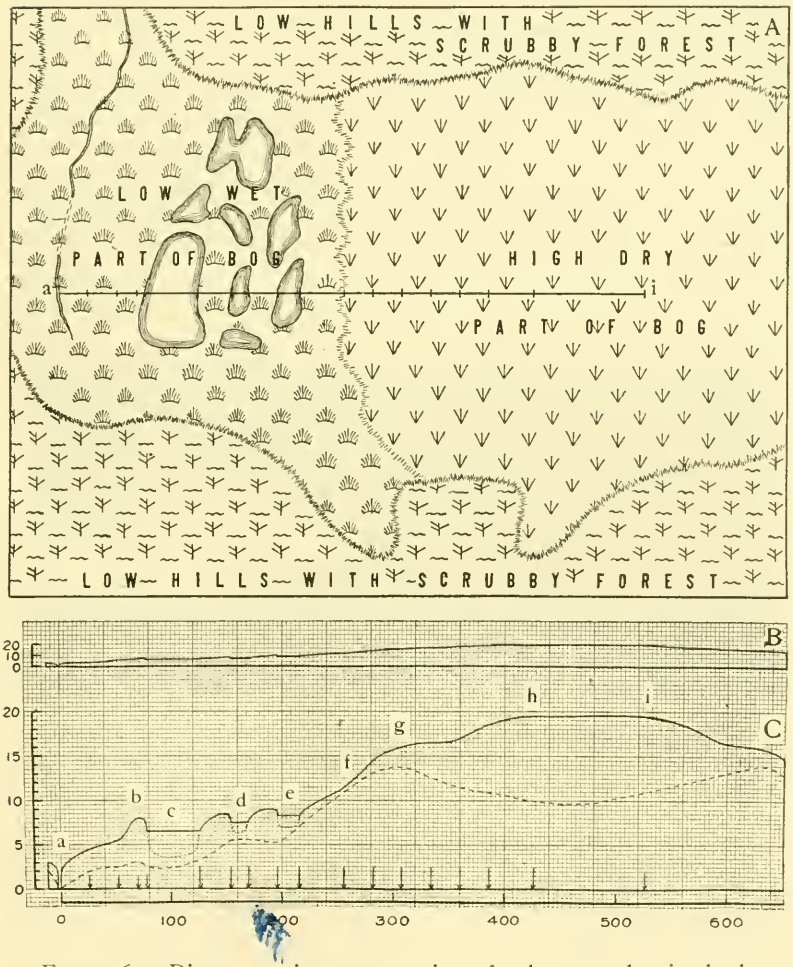


FIGURE 65.—Diagrammatic representation of a bog complex in the barrens; see text. *A*. Sketch map showing relation of area to adjoining upland. *B*. & *C*. Longi-sections along line *a–i* on map. Section *A* drawn to scale; in section *B*, vertical scale eight times the horizontal, and contour of rock floor indicated by dotted line. All measurements in feet. Arrows indicate location of soundings. Mountains west of Ingonish.

a. Development of Raised Bogs in and around Water-filled Rock Basins

An illustrative example.—In Fig. 65 is represented diagrammatically a bog-complex which was studied in some detail. Depth of peat, surface contour, and relations of the underlying topography were determined by means of sounding-rod and level. Section *B*, made along the line *a-i* in map *A*, is drawn to scale and shows the actual contour of the surface. Section *C*, identical with Section *B* but with the vertical scale eight times

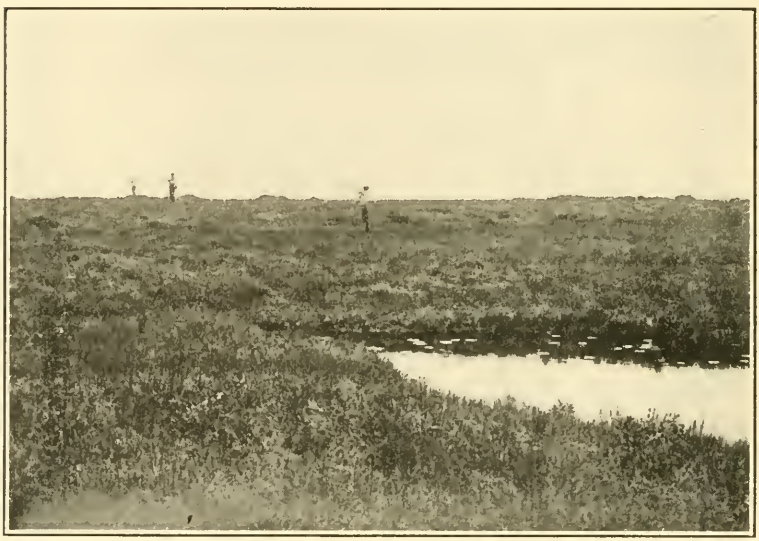


Figure 66.—Raised bog in barrens, mountains west of Ingonish; photograph taken from point between *d* and *e* in Fig. 65. In foreground, wet bog; figures standing on dry bog; see text.

the horizontal, brings out the relation between the surface contour and that of the rock floor beneath. It will be seen from this diagram (*f-i*, etc.) that the upper portion of the bog-complex (the portion pictured in Fig. 66) is occupied by a typical raised bog, which has been developed in and around a shallow rock-basin. Through the accumulation of peat, the surface has been built up more than six feet above the rim of the basin and about ten feet above its bottom, and has spread out over the rim. Attention may now be given to the manner in which this bog

has been formed, the lower portion of the complex (FIG. 65, *C*, *a-f*) being neglected for the moment.

The rock basin in question is situated at the summit of a low, rounded hillock which is bounded laterally by slightly higher hills. Partly as the result of direct precipitation, partly perhaps through surface drainage from the adjoining higher ground, this basin originally was kept filled with water, which spilled out over the rim at *g*. The manner in which this pond became obliterated was doubtless similar to what has been described in the general discussion of bogs a few pages back. The open water may have become filled in through the activity of the aquatic sphagnums, or through the encroachment from the margin of a floating mat, or through a combination of both these methods. Assuming the aquatic sphagnums to have been the pioneers, and that through their activity the pond had been more or less completely clogged up, the second stage in the succession was probably dominated by the mesophytic cushion-forming species (*S. papillosum, S. magellanicum, S. pulchrum*), although there may have been an intermediate stage of semi-aquatic species (*S. pulchrum, S. Dusenii*). Largely through the activity of the mesophytic cushion-forming sphagnums the surface may have been raised to a height of one or two feet above the former pond surface, at which point the xerophytic cushion-forming species (*S. fuscum, S. capillaceum tenellum, S. tenerum*) asserted themselves. It is to the species of this latter group that the further elevation of the bog surface to its present height has been largely due. Throughout this series of changes, various seed plants have occupied a more or less prominent position, and have played an important rôle by binding together and strengthening the ground-work formed by the sphagnums. The stages characterized by the predominance of the mesophytic and of the xerophytic sphagnums may be designated respectively the wet bog and the dry bog stages. The character of the surface vegetation in these two stages will be described later.

General observations.—The exact stage at which the central water body becomes obliterated in successions of the sort just described varies. In the present case, the pond has been overwhelmed so completely that there is absolutely nothing on the surface of the bog that even suggests its former presence. In other cases, however, the pond may persist for an indefinite

period, and may even be present on the higher parts of the mature bog. The factors concerned may be various, but of particular importance seem to be the depth of the basin to start with and the luxuriance with which the aquatic sphagnums develop. Where these latter are absent or poorly represented, so that the filling in is dependent on encroachment from the margin, the elimination of the pond proceeds slowly. For while the mesophytic, cushion-forming sphagnums may grow luxuriantly, forming great banks of vegetation around the edge of the pond, the centripetal advance into the pond of the fringing banks is usually slow. For this latter fact the commonly sparse development of the pioneer, skeleton-forming shrubs seems primarily responsible, since wherever an adequate shrubby framework is presented the sphagnums tend to push out from the shore quite rapidly. The banks of sphagnum commonly come to form a complete circle about the pond and block up any natural outlet which may have existed. (Of course, in the case of spring-fed ponds or of any ponds with a considerable outflow, the outlet may not become completely dammed, but such ponds are rarely concerned here in the development of raised bogs.) Thereafter drainage must be accomplished entirely by slow seepage through the peaty banks. As these banks are built up higher through the growth of the sphagnums at the surface, the peat underneath becomes more and more compressed by the superimposed weight and in consequence less and less permeable. The result is obvious: as the drainage becomes impeded below, the surface of the pond is forced to a higher level, and in this way, as fast as the surface of the bog is built upward, the pond likewise is shoved higher and higher, until ultimately it may come to lie at the crest of the mature bog. Concurrently with the changes just outlined, the bottom of the pond may likewise be built up through filling from within, but only when this latter process proceeds at a more rapid rate than that at which the surface of the pond rises can it have any immediate visible effect.

Mention has been made earlier of the convex surface which is possessed to a greater or less degree by all raised bogs. This convexity is most pronounced in bogs like the one just described, where there is a central pond which acts as a reservoir and from which water seeps out in all directions. It is self-evident that the areas nearest the pond will be best watered: it is here that

the sphagnums thrive most luxuriantly and grow most rapidly and that the surface of the bog tends to be built up the fastest and to the greatest height. Farther away from the pond, at least during dry spells, the water supply is less abundant, so that the rate of upward growth is slower and the height limit lower than in the more favorable central portions. The conditions, however, are not always as simple as are here suggested. Especially are complexities introduced through the development of ponds which are a result rather than a primary cause of bog development. Ponds of this "subsequent" type, as will be shown presently, are even more generally associated with raised bogs than are ponds of the "antecedent" type, like those just described.

β. Development of Raised Bogs over Flat or Irregularly Undulating Rock Surfaces

Perhaps more commonly than not, in northern Cape Breton, the rock floor which underlies a raised bog is essentially flat or else irregularly undulating: at any rate there are no rock basins capable of holding any appreciable amount of water. In the development of raised bogs in situations of this description, three more or less definite stages can frequently be distinguished, which may be designated respectively the *Bog Meadow* stage, the *Wet Bog* stage, and the *Dry Bog* stage. Owing largely to local variations in topography, the rate at which bog formation has progressed and the degree to which the raised bog climax has been approached varies greatly. All stages in the succession, which under favorable conditions culminates in the formation of the typical raised bog association-type, may be found, and, locally, any of the three types just mentioned may constitute an edaphic climax. Through the study and comparison of a large number of such areas, the general course or courses of development and the ecological relations of the association-types involved have been quite satisfactorily worked out. In the following account, attention is first directed to the chief features, vegetational and otherwise, of the respective stages, after which their relation to one another and to bog development will be discussed.

The bog meadow association-type.—As stated earlier, the surface of the tableland comprises a series of low, rounded hills, which rise to a rather uniform height and are separated by

valleys of varying depth, but mostly shallow. Many of these valleys (Fig. 67) are quite broad, with a nearly flat or slightly trough-shaped floor, and lie but little below the general level of the surrounding low hills. Lengthwise the floor may be nearly level, but commonly it slopes gently in one direction or another. The ground here for the most part is well watered, not only by direct precipitation but by surface drainage from the higher slopes. It is in situations of this sort that the bog meadow association-type is best developed.

Figure 67.—Broad, shallow valley in barrens; mountains west of Ingonish; occupied mainly by wet bog, but partly by bog meadow. In the background, low hills covered with forest scrub.

The outstanding characteristics of bog meadow are as follows. The predominant vegetation is grass-like, being made up chiefly of *Scirpus caespitosus* and *Calamagrostis Pickeringii,* with *Rynchospora alba* locally prominent. These plants form a thin, more or less continuous sward. Woody plants are relatively inconspicuous, but there is always a scattered growth of low shrubs, mainly *Myrica Gale, Andromeda,* and *Chamaedaphne,* which rise scarcely higher than the sedges, while the tamarack commonly is represented by occasional small stunted specimens.

The cushion-forming species of sphagnum are usually inconspicuous, although the substratum beneath the grasses and sedges is commonly carpeted, at least locally, with *Sphagnum Pylaisei* and *S. tenellum,* together with the liverwort, *Cephalozia fluitans.* The ground is covered by a firm turf, beneath which there usually is a layer of peat from a few inches to a couple of feet in depth. The peat is quite compact, consisting very largely of the remains of sedges and grasses, but usually with a matrix of sphagnum remains. The surface of the swamp is flat or undulating; it is relatively smooth, and not hummocky. Slight depressions in the substratum are frequent, and in some of these water may accumulate temporarily to the depth of a few inches, but there are few if any ponds of the sort to be described as characteristic of wet bogs. In addition to the three shrubs named above, *Kalmia polifolia, Vaccinium macrocarpon,* and *V. Oxycoccus* are commonly present, the two latter, as well as the species starred (*) in the subjoined list, being more characteristic of the depressions, particularly where, as is commonly the case, *Sphagnum Pylaisei* and *Cephalozia* form a more or less continuous, felty ground cover. Additional herbaceous vascular plants commonly met with in bog meadows are as follows:

*Schizaea pusilla**	*Drosera longifolia**
*Lycopodium inundatum**	*Drosera rotundifolia**
Eriophorum virginicum	*Bartonia iodandra**
*Carex oligosperma**	*Utricularia cornuta**
Carex exilis	*Solidago uliginosa*
Habenaria clavellata	*Aster nemoralis*
Sarracenia purpurea	*Aster radula*

The vegetation of the shallow depressions just referred to should perhaps be regarded as constituting a distinct association-type, but for convenience they are included here merely as a type of society.

The wet bog association-type.—This is commonly developed in situations similar to those indicated for the preceding type, but conditions are most favorable where the surface slope is slight and where the presence of shallow depressions or approximately horizontal surfaces affords habitats which are congenial to the local growth of the mesophytic cushion-forming sphagnums. The influence of topography is suggested by diagram *C* of Fig.

65, where area *a-e* is occupied by wet bog, and area *e-f* by bog meadow. Frequently, as here, the two types of swamp alternate on the same slope, while very commonly the wet bog which occupies the floor of a shallow valley (Fig. 67) is separated from the typical upland vegetation on either flank by strips of bog meadow.

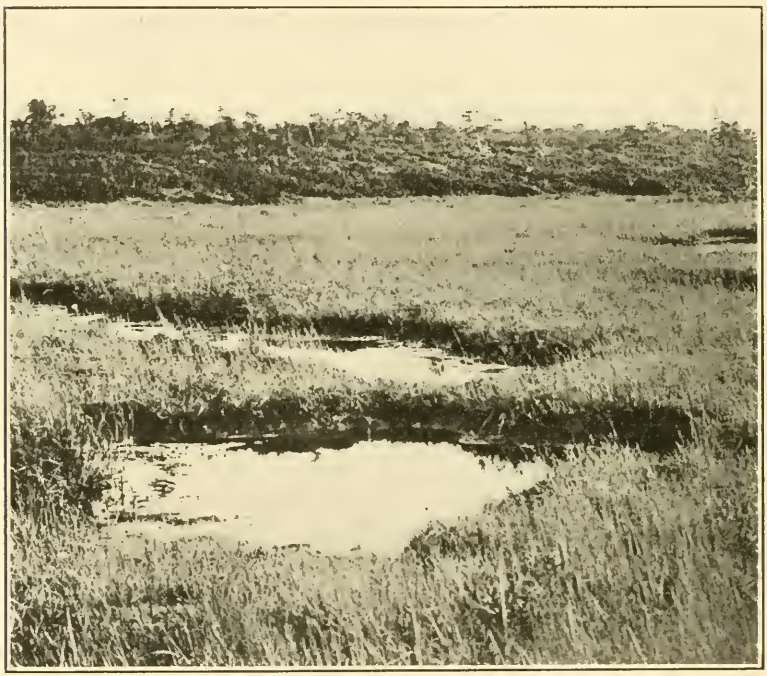


Figure 68.—In foreground, wet bog association-type (same area as that shown by Fig. 67), with pools due to activity of sphagnum (see text); in background, low hill covered with forest scrub; barrens in mountains west of Ingonish.

So far as the vascular element in the vegetation is concerned, the chief difference between this and the preceding association-type is seen in the relatively greater abundance here of the shrubs. Essentially the same list of seed plants is characteristic of each swamp type, and both shrubs (*Andromeda, Myrica, Chamaedaphne, Vaccinium Oxycoccus,* etc.) and herbaceous plants (*Scirpus, Rynchospora, Eriophorum,* etc.) are well represented

here. The following additional species might be mentioned as characteristic of wet bogs, although they may also occur to some extent in bog meadows: *Eriophorum callitrix, E. angustifolium, Carex pauciflora, C. paupercula, Smilacina trifolia.* Beside these, various of the species of dry bogs, not yet mentioned, may be sparingly represented. But the vascular plants are of subordinate importance to the sphagnums, and the fundamental dissimilarity between the vegetation of wet bog and that of bog meadow lies in the predominance here of these mosses. Foremost among the sphagnums are the mesophytic cushion-forming species (*S. papillosum, S. magellanicum,* and *S. pulchrum*). Growing in rich profusion, these latter form soft, wet, cushion-like or pillow-like beds which cover the ground almost uninterruptedly over large areas. Other species of *Sphagnum,* however, are by no means absent. Hollows in the bog proper are commonly occupied by societies of *S. tenellum* and *S. Pylaisei,* species which do not form cushions, while on the higher cushions, in greater or less abundance, may grow the relatively xerophytic cushion-forming species. In addition, the small ponds or pools which commonly dot the bog surface (Figs. 62, 64, 66, 68, 69) usually contain various aquatic and semi-aquatic species. These ponds constitute one of the most distinctive features of areas occupied by wet bog, but their vegetation, strictly speaking, belongs in quite a different category from that of the wet bog association-type (see further under discussion of successional relations).

The surface of a wet bog, viewed in its entirety, may be flat or slightly convex; viewed in detail it is more or less uneven and hummocky. It is commonly underlain by an accumulation of peat from two to four feet in thickness, which consists of an intimate admixture of sphagnum, sedge, and shrub remains.

The dry bog association-type.—This, the culminating association-type of the raised bog series, may develop in similar situations to the preceding but particularly or nearly level surfaces, either flat or undulating. In contrast to bog meadow and wet bog, perhaps the most striking features of a dry bog (Figs. 66, 69) are its usually convex shape, the luxuriant development of the xerophytic cushion-forming sphagnums (*S. fuscum, S. capillaceum tenellum* and *S. tenerum*), the presence of such xerophytic seed plants as *Empetrum, Gaultheria,* and *Vaccinium*

pennsylvanicum, and the predominance among the vascular plants of ericaceous shrubs. The bake apple (*Rubus Chamaemorus*) is one of the most characteristic plants of dry bogs. The surface of such a bog is hummocky, and except in wet weather the springy substratum underfoot is quite dry. The hummocks vary from one to several feet in diameter and from a few inches to more than a foot in height.[16] The depth of peat ranges up to more than six feet over a flat rock floor, while over depressions it may be considerably greater. Pools of the sort characteristic of wet bogs are found here also, but much less abundantly. Except for these and scattered wet depressions, whose vegetation and ecological relations are quite distinct from those of the enveloping area of dry bog (see later), the surface almost everywhere is overgrown by the xerophytic cushion-forming sphagnums, associated with which, and locally predominant, are certain other mosses (such as *Dicranum Bergeri, Racomitrium lanuginosum,* and *Polytrichum juniperinum*) and fruticose lichens (notably *Cladonia alpestris, C. sylvatica,* and *Cetraria islandica*). The moist hollows between the hummocks are commonly colonized very largely by liverworts, such species as *Ptilidium ciliare, Cephalozia media, Lepidozia setacea,* and *Mylia anomala,* which constitute more or less definite societies. The characteristic vascular plants of the dry bog association-type are the following:

Picea mariana
Larix laricina
Eriophorum callitrix
Scirpus caespitosus
Carex pauciflora
Myrica Gale
Sarracenia purpurea
Drosera rotundifolia
Pyrus arbutifolia atropurpurea
Rubus Chamaemorus
Empetrum nigrum
Nemopanthus mucronata
Cornus canadensis
Andromeda glaucophylla
Chamaedaphne calyculata
Gaultheria procumbens
Gaylussacia dumosa
Kalmia angustifolia
Kalmia polifolia
Ledum groenlandicum
Rhododendron canadense
Vaccinium Oxycoccus
Vaccinium pennsylvanicum
Solidago uliginosa

[16] Ganong remarks ('98, pp. 138, 139), that these sphagnum hummocks grow "in such rounded, radiating masses that it reminds one of the *Raoulia* or 'Vegetable Sheep,' and the resemblance is yet closer when, by drying, it assumes a grayish color."

It will be seen from the above list that nearly half the vascular species here are ericaceous shrubs or semi-shrubs, and these also comprise the greater bulk of the vascular plant cover. Herbaceous plants are subordinate in importance to shrubs, although a few forms, such as *Scirpus, Eriophorum* and *Rubus,* commonly occupy quite a prominent position. The various seed plants form a thin upper story of vegetation, but for the most part they rise less than a foot above the mossy substratum and quite commonly their shoots are buried nearly to the tip by the sphagnums. The trees are scattered and dwarfed: specimens of tamarack scarcely a foot high and an inch in trunk diameter may show more than fifty annual rings.[17]

---

[17] In this connection certain further observations by Ganong ('98, p. 142), equally applicable to Cape Breton bogs, are of sufficient interest and suggestiveness to warrant quoting at length. "Most of the ericaceous plants on the bog have stems of great length running just beneath the surface, which, as Warming points out, is characteristic of bog plants. In one, *Rubus Chamaemorus,* I followed a stem over seventeen feet without finding an end, and in *Ledum* and *Cassandra* for lesser, though considerable distances, also without finding the ends. These stems run nearly horizontally, branch frequently, and send out roots at intervals. The same stem varies in thickness in different parts; is now thicker, now thinner, showing a more active growth at some times than at others. It is clear, also, that these stems are now alive only at their tips, the under-moss parts being preserved from decay by their position. When one traces what appears to be a clump of young plants of *Ledum latifolium,* he often finds that they are all branches of one plant connected beneath the surface, and he cannot find the end of any one of them; and this is true also of other species. The question now arises, when and how have such plants started, and how do they come to an end? Since the different branches can grow on continuously, and, making their own roots, become independent of one another and of the original plant, and can grow upwards continuously with the growth of the moss, there seems to be no logical limit to their growth, and no cause for death, such as brings most other woody perennials to their end in other situations. Some of them may then be as old as the bog itself, and thus would be amongst the longest lived of phanerogamic vegetation. Yet a comparison between their age and that of a tree, for example, would not be a fair one; physiologically, their longevity should be compared rather with that of those lower organisms, which grow by continuous fission. This continuous life of the bog plants, however, is pure theory; its demonstration is attended with great practical difficulties. To some extent this mode of growth is found also in the trees. In the spruces . . . one may observe how the moss is rising and burying them. As it

Successional relations.—Assuming for the purpose of illustration a nearly level or gently sloping rock floor, approximately flat as a whole but in detail with a more or less irregular surface, with slight elevations and depressions but with no basins capable of retaining any appreciable body of water, the successive steps in the evolution of a raised bog may now be outlined. On an uneven rock surface of the sort under consideration the pioneer aspect of the vegetation varies locally. In the higher, drier situations it is essentially xerophytic. Commonly the vegetation here is that of the sedge–grass heath association-type, as described in connection with xerarch successions: the ground is covered by a carpet of cladonias and *Racomitrium,* and supports a more or less luxuriant growth of *Scirpus caespitosus* and *Calamagrostis Pickeringii,* with a scattering of low shrubs. In the lower situations the vegetation may be quite similar, but here, owing to the generally more favorable moisture relations, the sphagnums commonly establish themselves, either coming in at the outset or later on replacing the cladonias and *Racomitrium.* Subsequent changes in the nature of the substratum and in the ecological aspect of the surface vegetation depend very largely on the sphagnums, not merely on their presence or absence but on the species which come to predominate. Where conditions are such that none of the sphagnums are able to establish themselves in force, any further changes will probably conform closely with what has been described earlier in connection with xerarch successions. Where conditions are such as to favor the growth of the sphagnums and these assert themselves as one of the predominating elements of the plant cover, further changes depend very largely on which particular group of sphagnums gains control over the situation.

For the sake of simplicity there will be described a hypothetical example of what may be regarded as the logical sequence of association-types: a series in which the pioneer stage gives way to a bog meadow, which becomes superseded by a wet bog, which in turn gives way to a dry bog; and, in this connection, various

buries the lower branches, these put out new roots, turn upwards at their tips, and grow as independent stems. This growth probably, however, does not go on indefinitely, since the trees are ultimately overwhelmed and destroyed by the moss."

other possible lines of development will be pointed out. Let it be assumed, as is very commonly the case, that the low spots have become colonized by *Sphagnum tenellum* and *S. Pylaisei,* species which lack the cushion-forming habit. Under these circumstances the formation of peat and the building up of the substratum may take place very slowly, being due very largely to the accumulation of sedge remains. But, even at that, it takes place much more rapidly in these lower areas than on the higher ones. As the layer of peat in these lower areas becomes gradually thicker and the ground level is raised higher, the surface vegetation spreads out laterally and may override the higher areas; and in this way there may originate what has been described above as a bog meadow.

Further advance beyond the bog meadow stage of the succession is dependent primarily, either directly or indirectly, on the activity of various cushion-forming species of *Sphagnum.* Wherever conditions are congenial to the growth and spread of the mesophytic cushion-forming species (*S. papillosum, S. magellanicum, S. pulchrum*), bog meadow may gradually give way to wet bog. Indeed these species may have been the important ones from the very outset, so much so that the bog meadow stage in the succession may never have been developed. The factors which condition the presence or absence and the relative abundance when present of these species of *Sphagnum* doubtless have to do very largely with the amount of water available throughout the season, but it seems likely also, as suggested elsewhere, that the difficulty with which these and other species are able to invade areas already occupied by *S. Pylaisei* in particular may be a factor of considerable importance as affecting their establishment on the surface of a bog meadow.

The transformation in the character of the habitat accomplished through the agency of the mesophytic cushion-forming sphagnums and the manner in which they bring about the elimination of bog meadow or any other type of vegetation which may be present is exceedingly interesting. Heretofore, in the case of bog meadow, what water has not been absorbed by the compact, peaty substratum has been able to run off quite unobstructed over the comparatively smooth, firm surface, with the result that except during wet periods the ground at the surface may have been relatively dry. One of the essential characteristics of the

cushion-forming sphagnums is their great ability to absorb and retain liquids. But while this in itself is a factor of no little significance in hindering the loss of water, even more significant is the manner in which individual clumps of these mosses run together and form banks which may obstruct the drainage to such an extent that in favorable situations, as on gentle slopes, the water may be dammed back to form ponds and pools of various dimensions. The degree to which masses of sphagnums are thus able to hold back the water is remarkable. In the boggy area diagrammatically shown by Fig. 65, *C*, for example, the level of the water in the pond at *e* is nine inches higher than that at *d*, twenty-five feet distant; and the water level in pond *d* is twelve inches above that in pond *c*, equally distant. In another instance a difference in elevation of two feet was measured between two water surfaces thirty-five feet apart; while in two other cases differences in level amounting respectively to nearly ten feet in less than a hundred, and to more than one foot in three were estimated. On the "down-hill" sides of a pond the banks of sphagnum rise steeply from the water's edge to a height of one, two, or more feet above the pond's surface. In one instance a rise of three feet within seven feet of the water's edge (or to a height of about five feet above the mucky bottom of the pond) was noted. It is obvious that these ponds, by retaining much of the water which accumulates in them during wet periods, or which drains into them from higher levels, function as storage reservoirs and insure to adjoining areas a fairly uniform water supply throughout the season.

Incipient ponds of the sort just described are frequently encountered in the bog meadow stage of the succession, but there they are usually shallow and ephemeral. It is in the wet bog stage that they first attain a position of ecological importance. The formation of ponds hastens the elimination of the bog meadow as a distinct association-type, for their spread leads naturally to the extermination of any plants which may have tenanted the areas which they now occupy, except for the few species which are able to adapt themselves to the changed conditions, either by assuming an aquatic habit (e. g., *Sphagnum Pylaisei*) or through their position above the water level (e. g., tussocks of cushion-forming sphagnums).

Sometimes these ponds appear to be distributed quite indiscriminately over the surface of a bog (e. g., see FIG. 65, *A*): particularly is this true on the higher, older bogs. But in other cases their arrangement is very definite. To cite a specific illustration of the latter sort: in one shallow, approximately flat-floored valley (similar to that pictured in FIG. 67) about a hundred feet wide, there are ten of these ponds within a distance of three hundred feet. All are more or less elliptical in outline, twenty to fifty feet long by six to twenty feet wide, and they are arranged, like a flight of steps, at right angles to the long axis of the valley floor. Between the surface of the lower pond in the series and that of the upper there is a vertical difference in elevation of five feet. It may be further noted that the rock floor beneath this bog, as determined by soundings, is quite even and that the peat is uniformly about four feet deep, except around the down-hill margins of the ponds where it is banked up higher. From the study of this and other like cases, there seems little question that a large proportion of the ponds associated not only with wet bogs but also with dry bogs have originated in the manner here described. The absence of any relationship to the character of the underlying topography is exemplified by ponds *d* and *e* in FIG. 65, *C*.

Leaving for the moment the consideration of these ponds, the further history of the bog as a whole may be briefly detailed. Largely through the activity of the mesophytic cushion-forming sphagnums, the general level of the surface has been raised and bog meadow eliminated. These mesophytic sphagnums continue to predominate and to build up the substratum for a locally variable length of time: frequently a wet bog association may represent an edaphic climax. But although the nature of the environment may be considerably modified by the influence of the ponds referred to above, it is apparent that, as a rule, sooner or later, as the surface rises higher, the conditions will become less favorable for the mesophytic sphagnums, while at the same time they will become more favorable for the xerophytic cushion-forming species (*S. fuscum, S. capillaceum tenellum, S. tenerum*). As time goes on, these latter species, which in wet bog constitute merely a subordinate element in the vegetation, gradually become the predominant forms, and wet

bog becomes superseded by dry bog. Incidentally it may be remarked that, like the mesophytic forms, the xerophytic cushion-forming sphagnums sometimes predominate from the very outset, so that both the bog meadow and wet bog stages may be eliminated. On the higher, drier parts of a bog, as elsewhere indicated, the xerophytic sphagnums in turn may give way locally to various lichens and mosses, but these never become sufficiently abundant to constitute a distinct association-type.

Throughout the successive steps in bog development, as just outlined, sight must not be lost of the part played by various seed plants. These fulfill a triple rôle in that they facilitate the upward growth of the sphagnums and bind together the spongy, otherwise incoherent matrix of sphagnum remains, beside contributing in varying degree to the bulk of the deposit. Much of the springiness and comparative firmness which characterizes the surface of a mature bog is ascribable to the tangle of stems and roots with which the ground is interwoven. With regard to the rate at which the bog surface is built upward: in general, upward growth is comparatively slow at first, during the bog meadow stage, most rapid during the wet bog stage and during the early part of the dry bog stage, from which point on there is a gradual slowing down until, in the case of the older, higher bogs, growth is practically at a standstill (but see quotation from Weber on p. 456).

From the observations recorded in the preceding pages it is apparent that not only do the sphagnums as a class play an all-important part in the development of raised bogs, but that different groups of sphagnums are responsible for different phases in the development. It is also certain that the formation and upward growth of a bog is not dependent on the presence of any preëxisting water basin from which the required water is raised by capillarity. The view expressed by Ganong ('98, p. 148) that "The raised bogs are formed, as all students of them agree, by the pure Sphagnum growing upward and carrying the water by capillarity with it" has long since been exploded. To quote from Warming ('09, pp. 200–201): "It is erroneous to suppose that Sphagnum sucks up water from the soil; it raises water only for an inconsiderable distance. The movement of water in a Sphagnum-moor is essentially a descending one. The depth at which the water-table lies is dependent on the atmospheric precipi-

tation and upon the permeability of the peat and of the substratum . . . . . [A raised bog (high-moor)] often arises on top of old low-moor; it may also take origin on wet sand, and even on rocks if these be sufficiently wet." Incidentally, it is worthy of note that although he accepted the then current conception as to the origin of raised bogs, Ganong was puzzled by, and commented at some length on, the "presence of much standing water near the surface on the higher parts" of the New Brunswick bogs which he studied ('98, p. 148).

In this connection, it is also of interest that Ganong ('98, p. 151) describes as occurring on the slopes of one of these bogs "a series of remarkable holes . . . . of various sizes, from 30 by 12 feet down to a few inches. They are a foot or two deep, have perfectly level bottoms of black muck, sometimes so dry as to crack in the sun, in others moist, in others covered with water, the latter being at the lower, the former at higher levels." Obviously these are the ponds or pond holes which have been discussed at some length by the author. In northern Cape Breton also, the water in many of them disappears during a dry season, but many of them are several feet deep and apparently always contain water. The ponds on the higher parts of a bog are usually more or less circular in outline (Fig. 69) and ordinarily have steep banks all around. They may be relatively few in number, but commonly there are several or many to the acre. In many of them, save for various algae, vegetation is sparse and any filling in is accomplished through the gradual encroachment of the banks. In others there is a luxuriant growth of aquatic sphagnums (*S. Pylaisei, S. cuspidatum*). As regards the growth of these aquatic sphagnums, the discrepancy between different ponds is hard to account for, unless, as is very likely the case, it be correlated with the abundance of algae (see next paragraph). With the exception of *Nymphaea* and *Eriocaulon,* aquatic seed plants are usually scarce. In general, the ecological relations of the vegetation here approximate what has been described earlier (see: association-complexes of undrained ponds, p. 417; also, development of raised bogs in and around water-filled rock basins, p. 438).

Weber, in his paper on the vegetation and origin of the Augstumal Hochmoor in Prussia ('02, pp. 76–78), has made some important observations regarding the origin of these ponds

(*"Hochmoorteiche"*). Previous investigators for the most part had reasoned either that they represent the remains of lakes which formerly existed in the areas now occupied by bog, or, in view of the common paucity here of sphagnums, that they represent places where springs of lime-carrying water break through, a view which was somewhat doubtfully favored by Ganong. Parenthetically it may be suggested that the luxuriance with which the sphagnums, particularly *S. Pylaisei,* not infre-

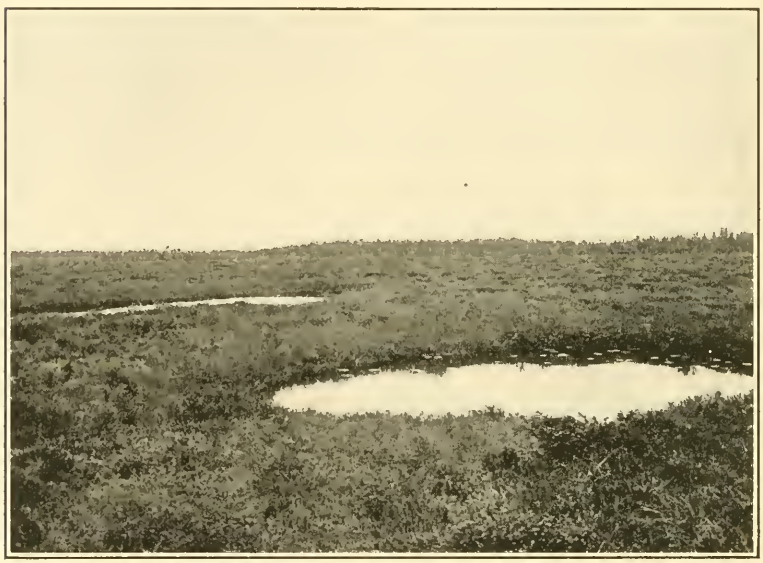


FIGURE 69.—Pools on surface of mature raised bog; Scotchman's Barren.

quently occupy such ponds in northern Cape Breton is of relevant interest in this connection. In discussing their origin, Weber points out that while undoubtedly the first explanation mentioned above is sometimes the correct one, the second one is largely based on insufficient investigation. He effectually disposes of this lime theory by making careful analyses of the water in the ponds, which he finds, like that in surrounding parts of the bog, to be extremely poor in inorganic salts. He therefore concludes that the source of water supply cannot come from the ground. He incidentally comments on the universal lack of any positive signs of springiness, an observation which the writer can con-

firm. Weber's explanation of the manner in which these ponds usually arise is somewhat as follows. They originate in the pools of water which collect in the deeper hollows between the hummocks on the surface, during wet seasons. During the dry season the water collects here only temporarily, but long enough to permit the existence of a number of low algae. The development of algae has a detrimental effect on the growth of any sphagnums which may be present, since (*op. cit.* p. 28) when the water dries up they form a thin parchment-like coat which overgrows the sphagnums and cuts off their light supply. When, in times of increased precipitation, the hollows fill up with water, wave activity brings about the enlargement of the basin, while by its mere weight, which in general is greater than that of an equal volume of water-soaked peat, the water contained in the basin causes the pond to deepen, an end which is also favored through the increasingly active circulation of oxygen through the water. He further remarks that while during subsequent dry periods numerous pools become overgrown again, in other cases the pools persist and become deeper as the surrounding surface of the bog rises higher. He consequently regards the deepest pools, in general, as the oldest ones.

Broadly speaking, Weber's explanation as to the origin of these ponds roughly approximates that arrived at independently by the writer. The essential points of both views are (*1*) the subsequent, rather than antecedent, origin of the ponds with reference to the bog; (*2*) the meteoric, rather than telluric, source of the water supply. The chief point of difference is this. According to the author's explanation, the ponds originate at a rather early stage in the bog's history and by their presence exercise an important influence on its development. Moreover, after their preliminary period of growth, there is little if any subsequent enlargement, but rather the tendency is just the reverse. According to Weber's explanation, the ponds may originate even on the surface of the mature bog. Moreover they are constantly tending to increase in size. So far as the raised bogs of northern Cape Breton are concerned, it is the opinion of the author that the majority of the ponds to be found on mature raised bogs have had a history essentially similar to what he has described. But it also seems very likely that some and quite possible that many of them may have originated in the manner suggested by Weber. At any rate, the writer agrees

with Weber that even a mature raised bog is far from being in a condition of permanent equilibrium. To quote Weber (*op. cit.*, pp. 77–78): "Die Teiche sind nach alledem ebenso . . . . Symptome der beständigen Veränderung, die die Oberfläche des Hochmoores unter dem wechselnden Einflusse erfährt, den die Witterung längerer Zeiträume auf die Vegetation und den Boden ausübt. Solange die natürliche Vegetation vorhanden ist, gleicht das Hochmoor gewissermassen einem langsam pulsierenden und auf die äusseren Einflüsse in eigentümlicher Weise reagierenden Organismus."

In brief summary of the successional relations of raised bogs, as developed on essentially flat or undulating surfaces, it may be stated that, in any given area, there may ensue a sequence of stages, starting with a pioneer stage, passing progressively through bog meadow and wet bog, and culminating in dry bog, which latter constitutes the climax stage of the complete series. But the series is not always complete. In an area occupied by dry bog, either or both of the preceding stages may have been omitted; while, on the other hand, either of these two stages may constitute locally an edaphic climax. The course of events is dependent primarily on the activity of certain groups of sphagnums and is conditioned by the presence of environmental conditions suitable to their growth. In the course of a bog's development, through the activity of the cushion-forming sphagnums, ponds are formed which, by conserving the water supply, bear a vital relationship to the bog's growth. It may be added that the growth of a bog is not entirely vertical. As it grows upward it spreads out laterally. A bog originating in an edaphically favorable area may spread out in all directions, eventually covering many areas which of themselves were not favorable to bog development. In this way, as has been repeatedly pointed out, a bog may invade an area occupied by forest and bring about the destruction of the latter. Instances of this sort have been frequently observed in northern Cape Breton.

3. The Formation-types along Streams

THE ASSOCIATION-COMPLEXES OF RAVINES AND FLOOD PLAINS

The ravine associations of the hydrarch series here in the highland, like those of the xerarch series, require no special treat-

ment, since on the whole the vegetation is essentially similar to what has already been described as characteristic of ravines in the lowland. Of special interest, however, are the association-complexes of flood plains.

Attention has elsewhere been called to the fact that on the plateau most of the streams for long distances flow through broad, shallow valleys, but little below the general level of the surrounding country. The floors of these valleys are nearly flat and gently inclined. The surface is only a couple of feet higher

FIGURE 70.—Shallow, flat-floored stream valley with characteristic vegetation; barrens in mountains west of Ingonish.

than the water in the stream in summer, and at times of high water it is subject to overflow. At such times a small amount of sediment is deposited, and this, together with the inundation itself, apparently has a decisive effect on the character of the vegetation. It therefore seems appropriate to regard such areas as flood plains, although they differ in a great many respects from ordinary flood plains. The mineral substratum is commonly overlain by a layer of peat one or more feet in thickness, which is rendered distinctly gritty by the fine sediment which

is infiltrated throughout the mass. The surface vegetation is essentially that of a well-drained swamp. Over considerable areas its ecological aspect is that of a meadow, with sedges and grasses predominating. But as a rule these swales or "hay marshes" alternate with equally extensive patches of alder thicket and swampy woodland (Fig. 70). Similar associations are encountered frequently around the small lakes which lie along the courses of the streams. Here all intergradations occur between typical well-drained swamps and bogs. Along the streams themselves it is only occasionally that patches of bog are encountered, even the plants peculiar to bogs commonly being absent. In the barrens, where especially these flat-floored valleys constitute a prominent topographic feature, the flood plain vegetation here contrasts sharply with that of swamps remote from stream activity. In this connection it is worthy of note that the species of *Sphagnum* which play such an important rôle in bog development are scarce or absent here, although certain other species of *Sphagnum,* e. g., *S. Girgensohnii, S. recurvum,* and *S. palustre,* together with such mosses as *Chrysophynum stellatum* and *Drepanocladus fluitans,* are commonly represented, though never developing in any great luxuriance. A list of characteristic vascular plants follows:

Osmunda Claytoniana
Abies balsamea
Picea mariana
Picea canadensis
Larix laricina
Agrostis hyemalis
Calamagrostis canadensis
Glyceria canadensis
Scirpus caespitosus
Carex stellulata
Carex crinita
Carex aquatilis
Carex pauciflora
Carex polygama
Carex oligosperma
Carex folliculata
Juncus sp.
Iris versicolor
Habenaria dilatata
Myrica Gale
Alnus incana
Spiraea latifolia
Pyrus arbutifolia atropurpurea
Amelanchier sp.
Rosa nitida
Viola pallens
Kalmia angustifolia
Chamaedaphne calyculata
Lonicera caerulea
Viburnum cassinoides
Solidago uliginosa
Solidago rugosa
Aster radula
Aster umbellatus

SUMMARY

Cape Breton is situated northeast of the peninsula of Nova Scotia. In northern Cape Breton two topographic regions can be distinguished: the Highland and the Lowland. The highland includes primarily the lofty interior plateau, which rises to an average elevation of more than a thousand feet and is underlain by crystalline rocks of Laurentian age. In places this extends clear to the sea, but along much of the coast there is an intervening border of Carboniferous lowland, of varying width, between the highland and the shore. The entire area has been glaciated, drift being encountered on all sides in the lowland but much less frequently on the plateau.

The climate of the region as a whole may be classed as cool temperate maritime. The climate of the plateau differs from that of the lowland in the lower mean temperatures, greater daily range of temperature, shorter growing season, heavier precipitation, and generally lower humidity, this latter being attributable in large measure to the prevalence of low-lying cloud banks.

Considered from a phytogeographical point of view, Cape Breton lies near the northern border of the Transition Forest Region of eastern North America. In northern Cape Breton, owing chiefly to the differences in climate mentioned above, both the Deciduous Forest Climatic Formation and the Northeastern Evergreen Coniferous Forest Climatic Formation are well represented, the former in the lowland, the latter in the highland. These formations, as developed in northern Cape Breton, are treated separately.

The scheme adopted in classifying the plant associations of these two regions is outlined in the table of contents and has been discussed in some detail in another paper (Nichols '17).

The regional climax association-type in the lowland is a mixed deciduous-evergreen forest, comprising sometimes a dozen different trees, of which the following species are most characteristic: *Fagus grandifolia, Acer saccharum, Betula lutea, Abies balsamea, Tsuga canadensis,* and *Pinus Strobus.* All of these trees grow vigorously and to good size. The woody undergrowth in the forest includes, as the commoner species, *Acer spicatum* and *A. pennsylvanicum, Taxus canadensis* and *Corylus rostrata.*

Thirty-five herbaceous vascular plants are listed as characteristic. Bryophytes are present in profusion, but on the forest floor they are sparsely developed. This latter fact apparently is correlated with the annual accumulation on the ground of a blanket of fallen leaves which prevents the development of a moss-carpet.

The permanency of this type of forest is indicated by the composition of the younger generation of trees, which, in general, conforms with that of the mature stand. In this connection the ecological status in these forests of the balsam fir, character tree of the northeastern evergreen coniferous forest climatic formation, is considered in some detail. The conclusion is reached that the inability of this tree to compete successfully with the trees which characterize the deciduous climax forest formation can be attributed very largely to its shorter tenure of life, coupled with its greater susceptibility to fungus diseases and possibly with its less pronounced tolerance of shade.

The trees which characterize forests of the regional climax type, not only here but elsewhere in the Transition Region, can be divided into five groups: (*A*) Deciduous species whose center of distribution lies south of the transition region; (*B*) Deciduous species whose center of distribution lies within the transition region; (*C*) Evergreen species whose center of distribution lies within the transition region; (*D*) Evergreen species whose center of distribution lies north of the transition region; (*E*) Deciduous species whose center of distribution lies north of the transition region. With reference to the presence or absence of representatives of the first four groups above specified, eleven floristically different types of forest are distinguishable (see p. 292). In general, the trees of groups *B* and *C* are about equally well represented in forests throughout the transition region, those of group *A* are most generally represented southward, those of group *D* northward. In many parts of the transition region black spruce replaces balsam fir as the predominant northern conifer. Black spruce does not appear to be specifically distinct from red spruce. It is very doubtful whether the various floristic subdivisions of the transition region that have been defined should be regarded as ecologically distinct. From the standpoint of ecological plant geography the vegetation of the transition region as a whole is best treated merely as a northward extension of the deciduous forest climatic formation.

The regional climax association-type in the highland is predominantly coniferous, *Abies balsamea* being by far the most abundant tree. Associated with this in the forest, but always of subordinate importance, grow *Picea canadensis, P. mariana, Betula alba papyrifera,* and *Pyrus americana.* Ten shrubs and twenty-seven herbaceous vascular plants are listed as characteristic. Bryophytes develop luxuriantly on the forest floor, forming an almost continuous ground cover.

The permanency of this type of forest is attested by the character of the younger growth which is essentially similar to that of the mature trees. All of the climax trees grow best in the open and reproduction is most prolific in openings of the forest due to windfall. But the reproduction, at least of the balsam fir and black spruce, is by no means confined to windfall areas, which seems to be the case farther inland, as on Isle Royale.

That the coniferous forest climax of the highland is a climatic and not an edaphic climax is evidenced by the gradual transition from deciduous to coniferous forest encountered in ascending the mountains, and by the practically complete absence on the plateau, even in edaphically favorable situations, of the climax trees of the deciduous forest climatic formation.

A detailed review of the character and successional relations of the various association-types which comprise the edaphic formation-complexes of the lowland and highland respectively will not be attempted here. An outline of these is afforded by the table of contents, at the beginning of the paper, and by the paragraph headings which are scattered through the text.

By way of brief general summary it may be stated that: in the lowland, associations of the regional climax type represent the culmination of successional series in all edaphically favorable situations. Elsewhere succession stops at a stage less mesophytic than the regional climax association-type: in other words, in such situations the edaphic climax association-type does not coincide with the regional climax association-type, as it does in the more favorable situations. Due largely to human activity many areas formerly occupied by forests of the regional climax association-type are now occupied by associations of a much more primitive character, notably by forests of white spruce and balsam fir. In the lowland the regional climax forests of the

highland are represented in successional series, in favorable situations being destined to give way to forests of the deciduous type but in many unfavorable situations constituting edaphic climaxes.

In the highland the same general relations hold true as in the lowland between associations of the regional climax type and those which are more primitive. But here, owing mainly to the humidity of the climate, the influence of dissimilar edaphic conditions is less pronounced than in the lowland. It can be stated in general that the influence of soil and topography on the character and distribution of plant associations is least pronounced in humid climates, most pronounced in arid climates: that this influence is universally proportional to the dryness of the climate.

The barrens represent an edaphic association-complex, the character of the vegetation being correlated with conditions of exposure, topography and soil. Of especial interest here is the extensive development of heath and of various types of scrubby forest and of raised bogs. Particular attention is called to the important part played in the development of the latter by different species of *Sphagnum*.

BIBLIOGRAPHY

Adams, C. C., 1902. Postglacial origin and migrations of the life of the northeastern United States. Jour. Geog. 1: 303-310, 352-357. *f. 1.*

Anrep, A., 1915. Investigation of the peat bogs and peat industry in Canada. Can. Dept. Mines Br. Publ. 351. pp. i-xii + 1-185. *pl. 1-92 + f. 1-65 + maps 1-29.*

Atkinson, G. F., 1905. A college text-book of botany. New York.

Bastin, E. S., and Davis, C. A., 1909. Peat deposits of Maine. U. S. Geol. Surv. Dept. Int. Bull. 376. pp. 1-127. *f. 1-18 + map.*

Burns, G. P., 1916. Studies in tolerance of New England trees. III. Discontinuous light in forests. Vermont Agr. Exp. Sta. Bull. 193. pp. 1-23. *f. 1-5.*

Cooper, W. S., 1911. Reproduction by layering among conifers. Bot. Gaz. **52**: 369-379. *f. 1.*

—— ——, 1912. The ecological succession of mosses, as illustrated upon Isle Royale, Lake Superior. Plant World **15**: 197-213. *f. 1-6.*

—— ——, 1913. The climax forest of Isle Royale, Lake Superior, and its development. Bot. Gaz. **55**: 1-44, 115-140, 189-235. *f. 1-55 + map.*

—— ——, 1916. Plant successions in the Mount Robson region, British Columbia. Plant World **19**: 211-237. *f. 1-8.*

Cowles, H. C., 1901. The physiographic ecology of Chicago and vicinity. Bot. Gaz. **31**: 73-108, 145-182. *f. 1-35.*

Davis, C. A., 1907. Peat: essays on its origin, uses and distribution in Michigan. Geol. Surv. Mich. 1906. pp. 93-395. *pl. 13-31 + f. 2-20.*

—— ——, 1910. Salt marsh formation near Boston and its geological significance. Econ. Geol. **5**: 623-629.

Duggar, B. M., 1909. Fungous diseases of plants. New York.

Fernow, B. E., Howe, C. D., and White, J. H., 1912. Forest conditions of Nova Scotia. Ottawa.

Fink, B., 1910. The lichens of Minnesota. Contr. U. S. Nat. Herb. **14**: 1-269 + i-xvii. *pl. 1-49 + f. 1-18.*

Fletcher, H., 1885. Report on the geology of northern Cape Breton. Geol. and Nat. Hist. Surv. Canada. Report of Progress. 1882-1884. pp. 1 H-98 H. *Maps 1-24.* Montreal.

Fuller, G. D., 1913. Reproduction by layering in the black spruce. Bot. Gaz. **55**: 452-457. *f. 1-6.*

Ganong, W. F., 1891. On raised peat-bogs in New Brunswick. Bot. Gaz. **16**: 123-126.

—— ——, 1893. A preliminary synopsis of the grouping of the vegetation (phytogeography) of the Province of New Brunswick. Bull. Nat. Hist. Soc. New Bruns. **5**: 47-60.

—— ——, 1897. Upon raised peat-bogs in the Province of New Brunswick. Trans. Roy. Soc. Can. II. 3^4: 131-163. *f. 1-9.*

—— ——, 1898. On the color of the water in New Brunswick rivers. Bull. Nat. Hist. Soc. New Brunswick **16**: 44-45.

—— ——, 1902. The vegetation of the Bay of Fundy salt and diked marshes. Bot. Gaz. **36**: 161-186, 280-302, 349-367, 429-455. *f. 1-16.*

—— ——, 1904. On some peculiar tree forms found in New Brunswick. Bull. Nat. Hist. Soc. New Brunswick **22**: 187-189. *3 figs.*

—— ——, 1906[a]. The nascent forest of the Miscou beach plain. Bot. Gaz. **42**: 81-106. *f. 1-14.*

—— ——, 1906[b]. On the physical geography of Miscou. Bull. Nat. Hist. Soc. New Brunswick **24**: 447-462. *f. 1 + map.*

Goldthwait, J. W., 1916. Physiography of Cape Breton Island, Abstract. Annals Assoc. Amer. Geog. **6**: 125-126.

Graebner, P., 1901. Die Heide Norddeutschlands und die sich anschliessenden Formationen in biologischer Betrachtung. In Engler, Die Vegetation der Erde. **5**. Leipzig. (Review by H. C. Cowles in Bot. Gaz. **35**: 293-294. 1903.)

Gray, A., Robinson, B. L., and Fernald, M. L., 1908. Gray's new manual of botany. Seventh edition. New York.

Harper, R. M., 1918. The plant population of northern lower Michigan and its environment. Bull. Torrey Bot. Club **45**: 23-42. *f. 1-3.*

Harshberger, J. W., 1911. Phytogeographic survey of North America. In Engler, Die Vegetation der Erde. **13**. Leipzig.

—— ——, 1916. The origin and vegetation of salt marsh pools. Proc. Amer. Phil. Soc. **55**: 481-484. *pl. 9-14.*

—— ——, 1916. The vegetation of the New Jersey pine-barrens. Philadelphia.

Harvey, L. H., 1903. A study of the physiographic ecology of Mount Ktaadn, Maine. Univ. Maine Stud. No. 5. pp. 1-54. *f. 1-6.*

—— ——, 1918. A coniferous sand dune in Cape Breton Island. Bot. Gaz. In course of publication.

Hawley, R. C., and Hawes, A. F., 1912. Forestry in New England. New York.

Howe, C. D., and White, J. H., 1913. Trent Watershed survey. Toronto.

Johnson, D. S. and York, H. H., 1915. The relation of plants to tide levels. Carnegie Inst. Publ. 206. pp. 1-162. *pl. 1-24* + *f. 1-5.*

Macoun, J. M., 1883-1902. Catalogue of Canadian plants. Geol. and Nat. Hist. Surv. Canada. I-VII.

—— ——, 1898. [Brief remarks, in "Summary report on natural history," on vegetation of Cape Breton.] Geol. Surv. Canada, Ann. Rep. N. S. **11**: 194A-200A.

Moore, B., 1917. Reproduction in the coniferous forests of northern New England. Bot. Gaz. **64**: 149-158. 1917.

Murphy, L. J., 1917. Seeding habits of the spruce as a factor in the competition of spruce with its associates. Plant World **20**: 87-90.

Nichols, G. E., 1905. *Schizaea pusilla* in Cape Breton. Fern Bull. **13**: 97-98.

—— ——, 1913. The vegetation of Connecticut. II. Virgin forests. Torreya **13**: 199-215. *f. 1-5.*

—— ——, 1915. The vegetation of Connecticut. IV. Plant societies in lowlands. Bull. Torrey Bot. Club **42**: 169-217. *f. 1-15.*

—— ——, 1916[a]. The bryophytes of Nova Scotia, with special reference to Cape Breton. Bryologist **19**: 38-47.

—— ——, 1916[b]. The vegetation of Connecticut. V. Plant societies along rivers and streams. Bull. Torrey Bot. Club **43**: 235-264. *f. 1-11.*

—— ——, 1917. The interpretation and application of certain terms and concepts in the ecological classification of plant communities. Plant World **20**: 305-319, 341-353.

Nichols, G. E., 1918. Additions to the list of bryophytes from Cape Breton. Bryologist **21**: 28-29.

Porter, J. B., 1917. Sphagnum surgical dressings. Internat. Jour. Surgery **30**: 129-135. *f. 1-8.*

Powers, S., 1914. Floating islands. Bull. Geog. Soc. Philad. **12**: 1-26. *f. 1-9.*

Rigg, G. B., 1916. A summary of bog theories. Plant World **9**: 310-325.

Robinson, B. L., and Fernald, M. L., 1909. Emendations of the seventh edition of Gray's Manual. I. Rhodora **11**: 33-61.

Robinson, C. B., 1903. Early intervale flora of eastern Nova Scotia. Proc. and Trans. Nova Scotia Inst. **10**: 502-506.

—— ——, 1904. Remarks on the flora of northern Cape Breton. Abstract. Torreya **5**: 15.

—— ——, 1906. Remarks on the flora of Nova Scotia. Abstract. Torreya **6**: 257-258.

—— ——, 1907. Contributions to the flora of Nova Scotia. I. Plants collected in eastern Nova Scotia in August, 1906. Bull. Pictou Acad. Sci. Asso. **1**: 30-44.

Rübel, E. A., 1914. Heath and steppe, macchia and garigue. Jour. Ecol. **2**: 232-237.

Shreve, F., 1917. A map of the vegetation of the United States. Geog. Rev. **3**: 119-125. *Map.*

Taylor, N., 1912. On the origin and present distribution of the pine-barrens of New Jersey. Torreya **12**: 229-242. *f. 1-2.*

Transeau, E. N., 1903. On the geographic distribution and ecological relations of the bog plant societies of northern North America. Bot. Gaz. **36**: 401-420. *f. 1-3.*

—— ——, 1905. Forest centers of eastern North America. Amer. Nat. **39**: 875-889. *f. 1-6.*

—— ——, 1905-1906. The bogs and bog flora of the Huron River Valley. Bot. Gaz. **40**: 351-375, 418-448; **41**: 17-42. *f. 1-16.*

—— ——, 1909. Successional relations of the vegetation about Yarmouth, Nova Scotia. Plant World **12**: 271-281. *f. 1-4.*

Warming, E., 1909. Oecology of plants: an introduction to the study of plant communities. Oxford.

Weber, C. A., 1902. Über die Vegetation und Entstehung des Hochmoors von Augstumal im Memeldelta. Berlin.

Whitford, H. N., 1901. The genetic development of forests in northern Michigan. Bot. Gaz. 31: 289-325. *f. 1-18.*

Yapp, R. H., and Johns, D., 1917. The salt marshes of the Dovey Estuary. II. The salt marshes. Jour. Ecol. 5: 65-103. *pl. 12-16* + *f. 1-13.*

Zon, R., 1914. Balsam fir. U. S. Dept. Agr. Bull. 55. pp. 1-68. *f. 1-8.*

For particulars regarding the previous Transactions of the Connecticut Academy,

Address the Librarian,
Andrew Keogh, Yale Station,
New Haven, Conn., U. S. A.

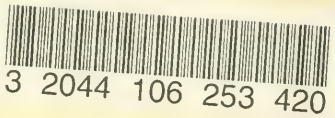
CONTENTS OF VOLUME 21 OF THE TRANSACTIONS

PAGES		PRICE
1–144	The Last Months of Chaucer's Earliest Patron, by Professor Albert S. Cook (Dec. 1916)	$1.60
145–200	The Relationship of the Tetracoralla to the Hexacoralla, by W. I. Robinson (Feb. 1917).....	.40
201–313	The American Species of Marchantia, by Alexander W. Evans (March, 1917).....	1.20
315–442	A Survey of Ancient Peruvian Art, by Philip Ainsworth Means (May, 1917).....	1.50

CONTENTS OF VOLUME 22 OF THE TRANSACTIONS

PAGES		PRICE
1–209	The History of Early Relations between the United States and China, 1784-1844, by Kenneth Scott Latourette (Aug. 1917)	$2.20
211–248	Studies in the Calcite Group, by William E. Ford (Oct. 1917)	.45
249–467	The Vegetation of Northern Cape Breton Island, Nova Scotia, by George E. Nichols (July, 1918).....	2.40

The last part of Volume 18 of the Transactions has not yet been published, but Volumes 19 to 22 are now complete. The Title Pages and Tables of Contents for Volumes 21 and 22 are distributed with the present article.


3 2044 106 253 420

Date Due

24Jan'51

MAY 1 4 1953

NOV 3 1953